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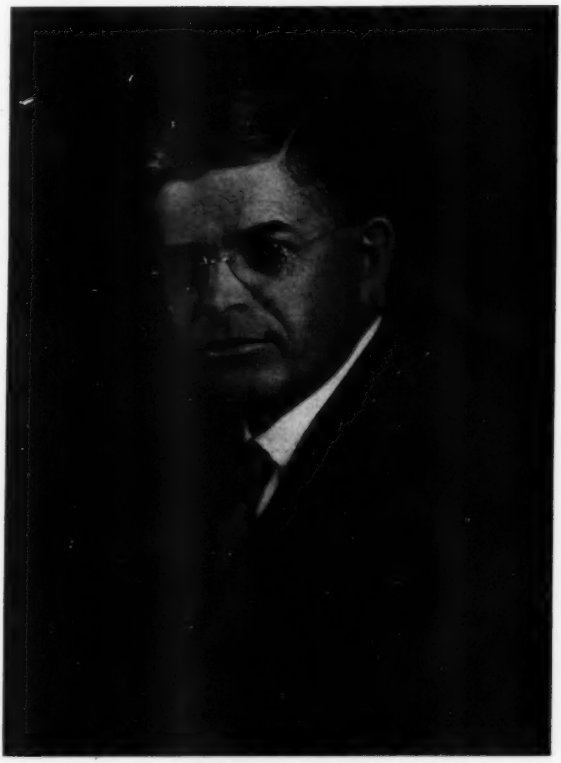


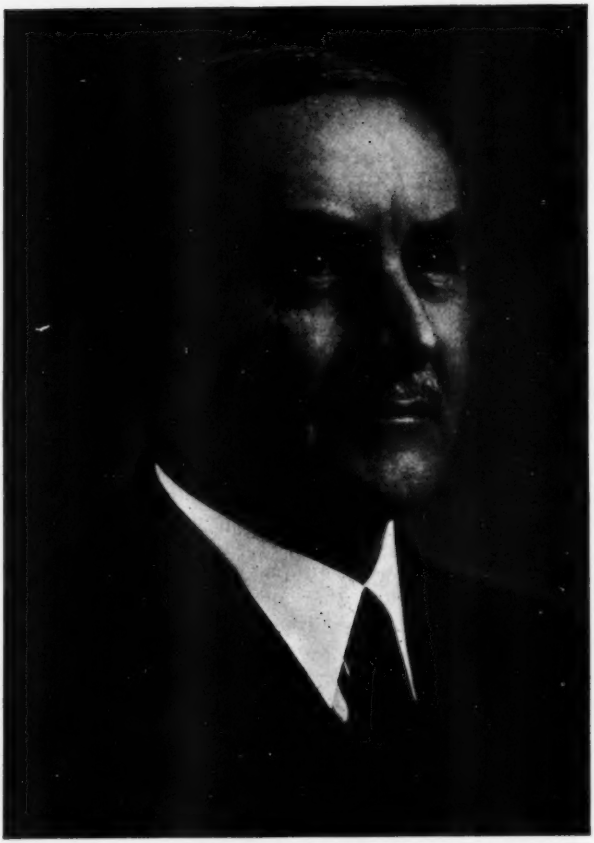
H. S. EVANS, President of the Society, 1931–32.

Herbert Silas Evans was born in Richardson County, Nebraska, July 20, 1875. He attended Morrill College, Kansas, for one year, 1891–1892, then entered the University of Nebraska in 1894, receiving his B.S. Degree in Electrical Engineering in 1898, and the E.E. Degree in 1900. In 1928, the University of Nebraska conferred on him the honorary degree of Doctor of Engineering. Mr. Evans was in charge of Electrical Engineering work for the Chi-

cago, Burlington and Quincy Railroads, Nebraska Division, from 1898 to 1901. From 1901 to 1905 he was Instructor and Adjunct Professor in Electrical Engineering at the University of Nebraska. He spent part of the year of 1905 in the employ of the General Electric Company, Schenectady, New York, and in September, 1905, was appointed Professor of Electrical Engineering at the University of Colorado. In the academic years 1909–1910 and 1918–1919 he was Acting Dean and was appointed Dean of the College of Engineering, University of Colorado, in September, 1919.

Dean Evans has been a Member of the American Institute of Electrical Engineers since 1905, Chairman of the Denver Section in 1919–1920, and filled the position of Vice-President for a term of two years—1929–1931. He joined the Society for the Promotion of Engineering Education in 1905, filling the position of Vice-President in 1920–1921, and was a member of the Council from 1922–1925. He holds membership in Sigma Xi, Tau Beta Pi, Sigma Tau, and Eta Kappa Nu.

Dean Evans was a member of the Boulder City Council for two six-year terms, from 1917 to 1929, and has been active in civic and church affairs. He is the author of numerous articles in engineering publications.



DR. W. J. KERR came to Oregon State as President in 1907 and established the School of Engineering the following year. He is completing a quarter of a century of inspiring and constructive leadership and has given to the State one of the great institutions of the West.

H. S. ROGERS, Dean, School of Engineering, Oregon State College.

HIGHER EDUCATION IN OREGON

By L. F. WOOSTER

In the February number of the JOURNAL an article was published about Oregon State College and the April number published one about the School of Engineering and Mechanic Arts at Oregon State College. Since these articles were published there have been, however, changes of far-reaching consequence in the organization of higher education in Oregon. In order to understand these changes and their significance, a brief survey of the factors leading up to them is necessary.

The early history of Oregon's institutions of higher education does not differ greatly from that of other states in which the State University, the Land Grant College, and the normal schools are separate institutions. The control of each has been in the hands of a separate board who became intensely interested in the welfare of the organization to which they gave their time and energy and whose viewpoint was necessarily provincial when that welfare seemed threatened. As the two major institutions grew, slowly at first, then more rapidly, each developed along different lines. As time passed a certain amount of duplication of courses and curricula was inevitable. In 1909 the State Legislature created a State Board of Higher Curricula with full authority to determine curricula matters for the two institutions and with the mandate "to determine what courses, if any, shall not be duplicated in the higher educational institutions of Oregon, and to determine and define the courses of study and departments to be offered by each such institution." By order of the State Board of Higher Curricula curricular changes were made at different times. The more notable among these were the elimination of engineering at the University; the allocation of all graduate work in applied science to the College and the allocation of all graduate work in pure science to the University.

In 1929 the legislature concluded that unnecessary duplication of courses between the two schools was still in existence and established the Oregon State Board of Higher Education with the assignment of the functions of all the former boards of regents and of the State Board of Higher Curricula which were, thereby, abolished. By this act the control of all of the public institutions of higher education in the State was placed in the hands of a "department of the government of the State." Every precaution

was taken to make this Board competent, non-partisan, and non-political. It was given full control, full authority, and full responsibility, and required to secure the assistance of some nationally recognized, impartial authority "in making a complete survey covering the present conditions and future needs of all branches of State supported higher education and scientific research in Oregon."

The United States Office of Education was asked to make this survey and agreed to do so, the agreement being signed on January 25, 1930. As directed by the new law a very comprehensive survey was made of all the State agencies for public instruction. This included not only the College and the University and the three Normal Schools but also in certain related matters the office of the State superintendent of public instruction and the public schools. The survey covered not only existing conditions and future needs but also the ability of the State to support education and the extent to which different fields of education should be developed. A three hundred page report of the survey was published as Bulletin (1931) No. 8, Office of Education.

A few statements quoted from the survey may indicate the trend of the volume. "Obviously unification rather than further diversification is the next step." . . . ". . . able to think in terms of a university of the State of Oregon with six campuses." "Oregon possesses the ability and resources, without crippling other State activities, to support an effective system of public education from kindergarten to professional schools that are equal to those of any other State." "Oregon is making expenditures for higher education on a scale proportionate with its wealth and income." "Distribution of functions should be on the basis of life careers." ". . . the normal schools shall train the elementary teachers and that the university and the Oregon State College shall prepare the high school teachers." ". . . lower division work in all the arts and sciences should be available on essentially identical terms at Eugene and Corvallis." "A great school of science should be developed at Corvallis." "The professional schools resting essentially upon the natural sciences should be located at Corvallis." "A great school of art, literature, and social sciences should be developed at Eugene, . . ." "The professional schools resting essentially upon the arts, literatures, and social sciences should be located at Eugene or at Portland." ". . . if the two units . . . were under one administration, very extensive use of single-faculty members upon both campuses would be developed."

Since the publication of the report of the survey by the Office of Education the State Board of Higher Education has given unlimited time and energy to the solution of its problems. Thousands

of pages of briefs have been submitted in discussion of major and minor points in connection with these problems. Up to date rulings have been made public covering only the skeleton of the reorganization. However, these rulings are indicative of the attitude of the Board. First came the decision that there is to be a Chancellor in charge of all State agencies for higher education. On March 7, the report of the Curricula Committee was adopted. This report visions the University at Eugene and the College at Corvallis as branches of the same institution. It divides the work of the two branches into major functions with a Dean or Director in charge of each function. In several cases a Dean or Director will have jurisdiction over work on both campuses. The headquarters of each Dean will be determined by the location of the major work. Major work assigned to the Eugene campus includes (1) Law, (2) Social Science, (3) Fine Arts, (4) Physical Education, (5) Business Administration and Commerce, (6) Literature, Languages, and Art. To the campus at Corvallis were allocated (1) Home Economics, (2) Agriculture, (3) Science, (4) Engineering, (5) Pharmacy, (6) Forestry. Training of high school teachers will be conducted by both branches with the Dean of the School of Education coördinating the work. The lower division work of both schools will be coördinated by a single director. Directors have also been appointed for General Extension work, Coöperative Extension, and Coöperative Research.

Many details remain to be worked out and some major points have not yet been decided. The outline indicates, however, that the completed organization will be an integrated system of higher education following in general the fundamental plan suggested by the Office of Education.

How does this reorganization affect the Engineering School at Corvallis? There is reason to believe that it will be strengthened rather than weakened. H. S. Rogers continues as Dean of Engineering under the new plan with increased responsibilities. The work in Chemical Engineering comes under his jurisdiction and possibly some work in Mining Engineering. No major change in the personnel of the Engineering School staff has been announced. The classification of work into lower and upper division work does not remove prescribed courses from the professional curricula. The concentration of work in biological and physical science on the Corvallis campus including graduate work can scarcely fail to strengthen graduate work in engineering. The concentration of social science and business organization at Eugene would have been a disturbing factor had not assurance been given that all necessary service courses for the professional schools would be retained.

Altogether it is an interesting development and one which will attract the attention of educators in all parts of the Country. In the meantime plans for the Fortieth Annual Meeting of the Society for the Promotion of Engineering Education are going forward. Local committees have been appointed and the Engineering School is preparing for a great convention.

COLLEGIATE COURSES FOR MANAGEMENT
A COMPARATIVE STUDY OF THE BUSINESS AND ENGINEERING COLLEGES

By CHARLES W. LYTLE
New York University, New York City

Introduction

This paper is the result of a study of collegiate education, embracing both business administration colleges and industrial engineering departments. On the former side it has drawn largely from a previous study made by Professor J. H. S. Bossard and Professor J. F. Dewhurst, and published under the title "University Education for Business." We wish here to express our indebtedness to these authors. On the engineering side the study has made use of certain findings by the S. P. E. E. Committee on Engineering Education, particularly where that study referred to Industrial Engineering. The original part of the work consists of a study of all engineering catalogs in the United States proper and of a questionnaire supplementary to this. We have not attempted to suggest any separate program for the business school, but have proposed such a program for the industrial engineering school.

In each phase of the study the business schools are treated first and the industrial engineering departments second. Thus the two types of schools are kept as nearly side by side as possible through the various phases such as: Origin and Development, Objectives and Curricula, etc. At the end we have tried to sum up the present problems together with proposed solutions for them.

An abstract of this paper is to be presented at the Fifth International Management Congress, Amsterdam, July, 1932. The study was undertaken for this purpose at the request of the American Committee for Participation in International Management Congresses.

"Managing is understanding, devising and persuading. It must see what is being done, what ought to be done, and what the fact and forces are through which or in spite of which it must be done."—H. S. Dennison.

Origin and Development of the Two Types of School

Origin of the Business College

The first college offering a specific course in management of any kind was the University of Pennsylvania, through the Wharton

School of Finance, established in 1881 at the recommendation of a Philadelphia business man, Joseph Wharton. He had no new science of business but he did have a definite objective. "All teaching must be clear, sharp and decisive, not languid or uncertain. The students must be taught and drilled, not lectured without care whether or not attention is paid. Any lazy or incompetent student must be dismissed." From the beginning courses were offered in accounting, finance, commercial geography, etc., which undoubtedly assisted men in their business careers. The curriculum did not, however, include much of the sciences or mathematics, and in this respect lost some of the advantages which had existed under liberal arts curricula.

Engineering Colleges Gradually Drawn into Management

The fact that all engineers, particularly mechanical engineers, had much to do with the improvement of machinery led them step by step into the improvement of machine operating, methods of work, control of factory conditions, and inevitably, the organization and control of human forces.

Preëminent in this movement was F. W. Taylor and his associate, H. L. Gantt, to whom most all developments in this work can be traced. The fact that Taylor lived in Philadelphia and was closely associated with Wharton does not signify that Taylor owed his ideas to Wharton. From the beginning the business and factory fields were distinct and only the effects of a single cause, that is, the emergence of large scale industry after 1879.

Origin of the Industrial Engineering Department

The earliest single course in shop management, so far as we can ascertain, was offered in 1902 at the University of Kansas and was taught by Hugo Diemer. Col. Diemer had previously written articles on the subject for Charles B. Going's Engineering Magazine and through these articles had become acquainted with Taylor. In 1907 General Beaver, ex-Governor of Pennsylvania and President of the Board of Trustees of The Pennsylvania State College, had a conversation with Taylor at the Union League Club of Philadelphia. Beaver told Taylor that he was looking for a man to head their M. E. Department, who could "teach M. E. from the standpoint of manufacturing rather than from the standpoint of power plant tests and higher mathematics." Taylor recommended Diemer and in this way Diemer became, in 1908, the head of the first Industrial Engineering Department in the United States. His first class of two men was graduated in 1911. In 1910, C. H. Benjamin, at the demand of alumni, started a department at Purdue

University and his first class of 50 was graduated in 1912. G. H. Follows of Carnegie Institute was the next to follow in 1912, producing a class of five in 1915. Cornell University, Massachusetts Institute of Technology and New York University followed in 1914, etc. At Cornell, D. S. Kimball had given a single course since 1904. He had returned to teaching after an interval in industry and was impressed with the careers of such engineers as C. C. Chesney, since in charge of all production in the General Electric Company. Kimball found it difficult to convince other faculty members that industrial engineering was a coming field but at the end of ten years he succeeded. At M. I. T., individual courses were begun in 1910 by C. F. Park, and at Lafayette College in 1912 * by E. O. Fitch; also at the University of Michigan in 1915 by J. A. Bursley.

Development of the Business College

The undergraduate business schools have increased from 7 in 1900 to 38 in 1928. These figures include only institutional members of the American Association of Collegiate Schools of Business. There are other schools giving full courses, but the Association includes the more prominent ones. As to the complete numbers of departments or divisions within the fields of accounting and administration, there were 182 in 1925 and around 400 which touched these fields in some way in 1929. The graduates from the 38 schools numbered 4,368 in 1928, with an additional 2,331 from graduate schools. The distribution of these men is best indicated by a survey of 10 schools made by the National Electric Light Association, covering 2,528 men.†

* This same year C. W. Mixter gave a single course at Yale but it was not continued.

† Public Utilities, a Survey, etc., p. 84, 1929.

Field	No. of Men	Per Cent of Total
General Business	873	34.5
Miscellaneous and Unknown	839	33.4
Banking	211	8.3
Public Utilities	152	6.0
Accounting	127	5.0
Merchandising or Retail	71	2.8
Manufacturing (aside from the rest)	62	2.5
Insurance	42	1.7
Teaching	42	1.7
Securities and Investments	41	1.6
Foreign Trade	21	0.8
Graduate Work or Research	21	0.8
Secretarial	13	0.5
Law	6	0.2
Real Estate	6	0.2
		100.0

Development of the Industrial Engineering Department

The number of engineering colleges with full I. E. courses have increased from 6 in 1914 to 35 in 1931. The 1931 graduates from 30 of these I. E. departments were 596.*

The ratio of the undergraduate I. E. men to the undergraduate Business Administration men can not therefore be more than 1 to 14 and if our figures on the latter were complete the ratio would probably be only about 1 to 20.

Analysis of Data from Questionnaires

The first groups to be graduated from Industrial Engineering courses ranged from 1 to 50 in number, as against all-engineers 26 to 338, and constituting on the average 10 per cent of all-engineers graduated from the same 30 schools. In 1931 the range for these same schools was, for Industrial Engineers, 0 to 115, and for all-engineers 32 to 635. The average class of Industrial Engineers was 20, and that of all-engineers for the same schools 142, the percentage having risen only to 14 per cent. 24 of these same schools have business colleges and turned out in 1931, 2,429 of these men, or an average class of 101. This group of schools in total produced nearly half of all the engineering graduates in the country and perhaps a third of the graduates from undergraduate business schools. We have not ascertained the complete number of graduates in 1931 for either of these groups throughout the whole United States, but a little over 12,000 seniors in engineering were reported just previous to graduation in 1931. Assuming that most of these men were graduated, the 596 Industrial Engineering graduates would represent only 5 per cent of all-engineering graduates. While this is a poor showing for Industrial Engineering it should be remembered that all engineering departments have been contributing to managerial positions. In a study † of engineering careers most of which were too mature to have been affected by Industrial Engineering courses, it was found that less than 1/3 of the men remained in strictly technical work and less than 1/10 of the men established themselves in an individual professional capacity. While the majority of graduates from all engineering courses do start in strictly technical work, an increasing number work over into some form of managerial duties until, after 15 years of practice, two out of three have stabilized in that work. A study of 334 graduates, all of whom were in the Engineering Administration Department at M. I. T., ‡ found the distribution of men

* 4 others have not been under way long enough to have graduates and 1 other failed to furnish data.

† S. P. E. E. Report of the Invest. of Eng. Ed., 1923–1929, Vol. I, p. 232.

‡ *The Technology Review*, March 5, 1930.

nine years out as follows: 46.2 per cent major executives, 28.1 per cent minor executives, 5.1 functional management, 5.1 sales, 5.1 miscellaneous, 7.7 technical and 2.6 per cent editorial, or 79.4 per cent managerial excluding sales.*

Classification of the Schools of Business Administration

The classification made recently by Messrs. Bossard and Dewhurst in their book already mentioned, is so satisfactory that we prefer to quote it in entirety and without additions.

1. *The Two-Year Undergraduate School.*—Twelve of the member schools are organized, at the present writing (1930), on a two-year basis, students being admitted to the school or college of commerce after having completed the first two years, usually in the college of liberal arts. The idea involved is the building of a two-year professional course upon a two-year liberal arts preparation, with a distinct administrative cleavage maintained. These twelve institutions are Chicago, Columbia, Indiana, Iowa, Kansas, Minnesota, Missouri, North Dakota, Northwestern, Texas, Washington University, and Wisconsin. It will be observed that all of these, with one exception, are situated in the middle west.

2. *The Three-Year Undergraduate School.*—Up to this time, only *two* institutions have developed a three-year school for business, an arrangement which is generally found in European universities. These institutions are the University of Georgia and Washington and Lee.

3. *The Four-Year Undergraduate School.*—These institutions admit students directly from secondary schools and maintain a control over the students during the four years of collegiate grade. *Twenty-three* of the member schools are of this kind, including Alabama, Boston, California, Denver, Florida, Georgia Tech., Illinois, Kentucky, Marquette, Nebraska, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Pittsburgh, Southern California, Southern Methodist, Syracuse, Tulane, Virginia and the University of Washington.

4. *The Five-Year Undergraduate School.*—Since 1920, the work of the College of Commerce of the University of Cincinnati has been conducted wholly on the coöperative plan, extending over a five-year period. The School of Commerce of the Georgia School of Technology, which maintains a regular four-year course in Commerce, also offers a five-year cooperative plan. In this connection, mention should also be made of the fact that the College of Business Administration of Boston University now maintains control of its students for a fifth year, which is devoted to supervised employment. In other words, to the four years of class attendance there is now added a fifth year of satisfactory supervised employment before the baccalaureate degree is given.

5. *The Undergraduate-Graduate School.—Two* institutions, Dartmouth College and the University of Michigan, maintain schools of business whose two years of instruction extend into both the undergraduate

* For data on the 1930 earnings of mechanical engineers, see *Mechanical Engineering*, Sept., Nov., Dec., 1931, and Jan., 1932.

and graduate levels. They are undergraduate in the sense that they admit only such students as have completed three years of work of college grade. Since the school's project includes a year of graduate work and since holders of baccalaureate degrees are admitted, they are also graduate schools.

Mention should be made at this point of the fact that the School of Commerce and Administration of the University of Chicago now conceives itself an undergraduate-graduate school, placing its emphasis upon a three-year program beginning with the junior year. Since the work of this school still is mostly on the traditional two-year basis, Chicago was included among the two-year undergraduate schools. There is a similar tendency in the school of business at Columbia University.

6. *The Graduate School.*—Harvard and Stanford maintain graduate schools of business to which selected holders of baccalaureate degrees are admitted, whether of an arts college, engineering school, business school, or other recognized branch of university education.

Certain qualifications are necessary, however, in referring to the above as graduate schools of business. They are not graduate schools of business in the sense that they presuppose or require an undergraduate training or curriculum in business studies, rather must they be thought of as schools offering instruction in business subjects at the graduate level. It has been pointed out previously that these are not the only schools which offer graduate work in business. Such universities as Columbia, Chicago, Illinois, and Pennsylvania have each a considerable number of graduate students in business courses.

As samples of good practice we submit the curricula of Columbia University and the University of Illinois, representing classifications (1) and (3) respectively. These two classifications embrace the great majority of the whole.

EXAMPLE OF TWO YEAR UNDERGRADUATE COURSE IN BUSINESS ADMINISTRATION

Curricula of Columbia University

One set of single courses is required for the first year (3d or 4th year in college) as follows:

Accounting 1–2	3	credit	hours	each
Banking 1–2	2	"	"	"
Finance 1–2	2	"	"	"
Statistics 1 or 101 *	4	"	"	"
Geography 1–2 †	3	"	"	"
Economics 17–18 or 23–24†	2 and 3	"	"	"

In the second year of study the only required course is Law b1–b2. Aside from this the students choose their own programs, subject to advice and guidance. Because the vast majority of Co-

* Recommended for students who have completed college algebra and who wish to carry statistics beyond a single semester.

† If not completed previously.

lumbia courses are graduate, properly qualified undergraduates are permitted to elect such courses, although they are not permitted to attend seminar courses, courses devoted to research, or courses in which the instructor plans his work strictly for graduate students. In most cases, there is a statement to this effect included in the description of the course. Most of the undergraduate students do not specialize or major even in their second years, preferring to generalize. The fields which hold greatest interest for them are, banking, accounting, finance, merchandising or marketing, advertising and statistics. Transportation, too, is often elected. The combinations of courses are innumerable and there are hardly two programs exactly alike.

A student who wishes to keep his program general might select, during his second year, a course from each of the fields enumerated above. As an example: a student who has merchandising definitely in mind might build up a program including Marketing 1–2, Marketing 103–104, Marketing 105–106 and Advertising 1–2. Dean J. C. Egbert says, "We try to help the student decide what particular phase of business he prefers and with courses in that field as a nucleus, we build up a program of supporting courses. Unless a student prefers to generalize it is inevitable that he include graduate courses in his program. Each student may be said to be an individual case. For this reason, too, we have, on pages 18–21, of our School of Business announcement,* suggested groupings of subjects covering various fields of study."

These fields are:

Accounting
Banking
Foreign Trade and Consular Service
Insurance
Labor Administration
Merchandising
Statistics
Transportation

EXAMPLE OF FOUR YEAR UNDERGRADUATE COURSE IN BUSINESS ADMINISTRATION

Curricula of the University of Illinois

The curricula in Commerce and Business Administration are: (1) General business; (2) trade and civic secretarial service; (3) banking and finance; (4) insurance; (5) accountancy; (6) general railway administration; (7) railway transportation; (8) commercial teaching; (9) foreign commerce; (10) industrial administration; (11) public utilities; (12) commerce and law. The first only is given here.

* See this publication for detailed descriptions of courses.

General Business Curriculum

First Year

First Semester	Hours	Second Semester	Hours
Acc'y 1a or 1e—Principles of accounting*	3–2	Acc'y 1b Accounting procedure	3
Econ. 22—Economic History of the United States	3	Econ. 27—Modern Industry	3
Rhet. 1—Rhetoric and Themes	3	Rhet. 2—Rhetoric and Themes	3
Military Drill and Theory	1	Military Drill and Theory	1
Phys. Ed.	½	Phys. Ed.	½
Hyg. 1	½	Hyg. 3	½
Electives	4–8	Electives	4–7
Total	15–18	Total	15–18

Second Year

Acc'y 2a—Elementary Cost Accounting	3	Acc'y 2b—Intermediate Accounting	3
Econ. 1—Principles of Economics	5	Econ. 3—Money, Credit, and Banking	3
Military Drill and Theory	1	B. O. and O. 1—Industrial Organization and Management	3
Phys. Ed.	½	Rhet. 10—Business Letter Writing	2
Electives	5½–8½	Military Drill and Theory	1
		Phys. Ed.	½
		Electives	2½–5½
Total	15–18	Total	15–18

Third Year

B. O. and O. 2—Marketing Org. and Operation	3	Bus. Law 1b—Principles of Business Law	3
Bus. Law 1a—Principles of Business Law	3	Econ. 10—Corporation Management and Finance	3
Trans. 1—Economics of Transportation	3	Electives	9–12
Electives	6–9		
Total	15–18	Total	15–18

Fourth Year

B. O. and O. 7—Salesmanship.	2	B. O. and O. 8—Advertising	3
or		or	
B. O. and O. 8—Advertising	3	B. O. and O. 7—Salesmanship	2
Advanced Economics (Junior or Senior Courses)	3	Advanced Economics (Junior or Senior Courses)	3
Electives	9–13	Electives	9–13
Total	15–18	Total	15–18

See announcement for detailed descriptions of courses.

* Those students who offer bookkeeping for entrance credit should take Acc'y 1e instead of 1a.

Objectives and Curricula of the Business Administration School

Fields of Specialization

Single courses in business administration amount to 1,968 in number when all different names are counted, but the true number would be much less if course names were thoroughly standardized. Bossard and Dewhurst claim that there are only six fields of business which are recognized as of prime importance: business law, statistics, marketing, accounting, money and banking, and business or corporate finance. Fields of secondary importance are: business English, labor problems, business organization and management, economic theory, selling and personnel administration. The majority of the schools offer 8 or more main fields of specialization. Close to half of the students confine their choice to the general business courses and in the interest of better teaching the business school educators are well agreed that more stress should be given to the fundamentals of business and less to the specialties.

Basic Subjects in Curricula

There are certain subjects which are given in common by most of these schools. Economics is invariably required in the freshman year and may or may not be followed by more advanced treatments of the same subject. English in some form, usually commercial correspondence, and sometimes public speaking, are more stressed today than formerly. Commercial geography is considered basic in that it describes resources of importance to all business. Mathematics, treated as a means of measuring, is given for the sake of mental training. Natural sciences are recommended for the same reason but can only be given in the longer courses. Courses in political science or business law are usually given to show the relationship of government to business and are considered to have considerable value. Applied psychology and sociology are important to acquaint students with the human aspects of business. An orientation course is deemed important to assist the student in selecting his field of electives. Beyond this no two schools have the same pattern.

Contacts With Industry

Twenty-one of the member A. A. of C. S. of B. Schools have formed bureaus of business research to furnish case material for business courses. This method is extremely important for graduate students, but has been none too successful with undergraduates. The project method, although more ambitious in one sense than the case method, is more suitable for undergraduate work. This may

be used by means of the coöperative plan, as at the University of Cincinnati, or by merely requiring each student to make one study within a particular company, as at the University of Chicago. The former school finds it necessary to offer only four fields of specialization because the students find unlimited opportunity for individual specialization through their coöperative work. A few schools are either requiring or assisting students to secure summer employment upon which periodic reports must be written.

Effective Teaching

After all, the major problem is how to teach effectively rather than how to gather information. Educators of the business schools are frank in conceding their difficulty in getting mental discipline from some of the business subjects. The fact, however, that these educators are alive to this weakness and are definitely trying to train for precise analytical thinking is encouraging. This should not be misinterpreted as a tendency toward more detail. If anything the tendency is away from the trivial sort of detail which has characterized so many text books. The steady accumulation of knowledge in every field and an increasing number of fields, makes it essential that both text and classroom treatment be carefully selected. With the emphasis transferred from mere knowledge to mental discipline, the lecture method is giving way somewhat to the method of assigning exercises which will give drill in analysis and which will cultivate work habits. This method is particularly feasible for accounting and statistics. Of course this method requires better teachers and more individual work. It also leads to better coördination of teachers and of departments because many problems cannot be confined within water-tight compartments. Incidentally, the tendency to overlap between courses may be obviated. Where the enrollment is large, classes should be broken down to 15 or 20 students, in fact they can be segregated on ability levels which permit the right tempo of work for each level.* This latter feature is still rare and its objective sought more commonly by the "honors" system. This system allows any senior, and sometimes any junior, who maintains an honor grade to absent himself from formal class work in order to pursue his work according to individual interests. Such men are required to pass the regular examinations and to consult with their course instructors. As a matter of fact they attend class more frequently than might be expected. Finally, there is a tendency to use the methodology, which has come from the use of case studies, to follow up graduates in order to remodel curricula on more efficient lines.

* See Learning and Living in College, by Dean Seashore, Un. of Iowa.

Classification of Schools of Industrial Engineering

Any scheme of classification would be subject to many exceptions. We have found it convenient to classify arbitrarily the engineering schools offering work in management as follows: *

I. *Full Management Course with Management Degree*

In this group there are 21 colleges, although one, Columbia, has as yet no graduates in this category. Massachusetts Institute of Technology has instead of one program, four slightly differentiated programs adapted respectively to the Civil, Mechanical, Electrical and Chemical fields. The State College of Washington has three differentiated courses, one each for the Civil, Mechanical and Electrical fields. The University of Nebraska gives most of its management work as a fifth year in its College of Business Administration, and after the completion of any of the older engineering courses. The rest of the group give a single sequence of courses. As a sample of this group the curricula of Ohio State University is submitted.

II. *Full Management Course With other Than Management Degree*

A. General Degree.
B. With the B.S. in Mechanical (etc.) Engineering, or Mechanical (etc.) Engineer.

The sub-group (*A*) includes such courses as that of Columbia University which grants the Master of Science Degree to those men who have spent two years in the Arts College and three in engineering management. The sub-group (*B*) is typified by Purdue University which gives about half as much Industrial Engineering as the schools of the first group but reaches a larger number of men than most schools in that group. It does not differentiate in the degree; in other words, it gives the B.S. in M.E. or B.S. in E.E. degree. The curriculum of this school is submitted as a sample for group II.

III. *Single Management Courses Required*

A. Through four years.
B. Through three years.
C. Through two years.
D. Through one years.

It will be noticed that some of the schools appearing in groups I and II also appear here. In fact, it is possible that more of these

* The full list of schools is presented later, excepting Class IV.

should be included but have been omitted due to the difficulty in finding the information in the catalogs.

IV. *Single Management Courses Elective*

A. Through four years.
B. Through three years.
C. Through two years.
D. Through one year.

Under *A*, *B* and *C* many of the schools again appear and under *D* nearly all appear. While effecting relatively few subjects, the elective system is almost universal, and at the same time infinitely irregular. For these reasons we have despaired of compiling an accurate list and do not offer any.

Schools Not Classified

There are some schools, such as the University of Minnesota, offering combination courses of two years in the Engineering College and two years in the School of Business Administration. There are others, such as Rutgers University, which require management subjects in engineering courses, but which deny having any Industrial course. There are also a few schools which give little or no management work during the engineering course, such as Harvard University and the University of Texas, but offer a fifth year of all management, usually in the School of Business Administration. Antioch College, with neither a business school nor an engineering school in the accepted sense, places all its students in business by means of a coöperative plan. It has its own business code which it stresses and, for all practical purposes, is turning out numerous graduates fairly well prepared for management. Within the classification there are many other shades of difference.

The first three classes of these schools are listed completely in Table 1.*

* In the first two groups the degree of each school is given in the abbreviated letters. In the remaining groups the abbreviated letters refer to departments other than Industrial Management and the Arabic numbers refer to the years in which single courses are given for such departments. That is:

1. Freshman year.
2. Sophomore year.
3. Junior year.
4. Senior year.

No attempt is made to show what or how much is given per year.

TABLE I

Engineering

I. *Full Management Course with Management Degree*—I.E., B.S. in I.E., B.S. in Business Administration, B.S. in Industrial Management, B.S. in Commercial Engineering, or B.S. in Business and Engineering Administration.)

University of Akron—I.E.
Alabama Polytechnic Institute—B.S. in I.E.
University of Alabama—B.S. in Ind. Mgt. (also 4 years in Com. Eng.).
Columbia University—B.S. in I.E. (also 5 years with M.S.).
University of Kansas—B.S. in I.E.
Lafayette College—B.S. in Adm. Eng.
Lehigh University—B.S. in I.E.
* Mass. Institute of Tech.—B.S. in Bus. and Eng. Admin., offers 4 differentiated courses for Civil, Mech., Elec., and Chem.
* University of Nebraska—B.S. in Comm. Eng. (a fifth year 5/8 of which is in Col. of Bus. Admin., after any eng. course).
No. Carolina State College of Agri. and Eng.—B. S. in I.E. (just started I.E. course).
Northeastern University—B.S. in I.E.—5 years.
Ohio State University—Bach. of Ind. Eng. (also Com. courses).
Oklahoma Agri. & M. College.
Oregon State Agri. College—B.S. in Ind. Shop Admin.
Pennsylvania State College—B.S. in I.E.
University of Pittsburgh—B.S. in I.E.
Syracuse University—B.S. in Adm. Eng.
Virginia Polytechnic Institute—B.S. in I.E.
University of Utah—B.S. in Comm. Eng.
State College of Washington—
(*a*) B.S. in Mgt. Eng. optional for C.E. at middle of course.
* (*b*) B.S. in Commercial—M.E.
* (*c*) B.S. in Commercial—E.E.
University of Washington—B.S. in Comm. Eng.

II. *Full Management Course With Other Than Management Degree* (General, or B.S. in M.E., etc.).

A. With General Degree (M.S., or B.S.,—B.S. in Eng.).
Carnegie Institute of Technology—B.S.
The Citadel—Bach. of Sci.
Manhattan College—B.S. in Eng. (5th year I.E.).
Yale University—Bach. of Sci.

B. With Other Engineering Degree (M.E., etc., B.S. in M.E., etc.).
Cornell University—M.E.†
University of Detroit—B.S. in M.E.
Georgia School of Tech.—B.S. in M.E.
State University of Iowa—B.S. in M.E.
Kansas State College—B.S. in M.E.
University of Michigan—B.S. in M.E., E.E., or Ch.E., 5 years.
University of Montana—B.S. in C.E., E.E., or M.E.
New York University—B.S. in M.E.
Purdue University—B.S. in E.E., or M.E.
West Virginia University.

* Not included in group statistics.

† Since writing the above Cornell has proposed to grant the degree of B.S. in Adm. Eng. hereafter. See S. P. E. E. Journal, Nov., 1931.

III. *Single Management Courses Required—*

A. Through 4 Years

The Royal Military College—1, 2, 3, 4.

B. Through 3 Years

Columbia University—3, 4, 5, C.E.
Marquette University—2, 4, 5, all depts.
New York University—2, 3, 4, A.E.

C. Through 2 Years

Brooklyn Polytechnic Institute—3, 4, M.E.
Colorado School of Mines—3, 4, all students.
Columbia University—4, 5, Mining Eng.
University of Missouri—3, 4, M.E.
New York University—2, 4, M.E.
Ohio Northern University—3, 4, all engineers.
Stevens Inst. of Tech.—2, 4, M.E.
University of Tennessee—3, Commerce, 4, M.E. and Ch.E.
Worcester Polytechnic Inst.—3, 4, Ch., Elec., Civil and M.E.

D. One Year Only

University of Alabama—4, A.E., Com.E., and M.E.
University of Arizona—4, M.E.
University of Arkansas—4, M.E.
Armour Inst. of Tech.—4, E.E., C.E.
Brooklyn Polytechnic Inst.—4, E.E., or 5 Ch.E.
Case School of Applied Science—4, M.E.
University of Cincinnati—4, A.E., C.E., E.E., M.E.
Colorado Agricultural College—4, M.E.
University of Colorado—4, M.E., E.E.
Columbia University—4, E.E., 5, M.E., and Ch.E.
Cooper Union—4, All Engineers.
University of Dayton—4, C.E., E.E., M.E., Ch.E.
University of Delaware—4, all except Chem.
University of Florida—4, all engineers.
Harvard University—4, M.E., E.E., C.E., Mining Eng.
Johns Hopkins University—4, all.
University of Idaho—4, C.E., E.E., M.E., Ch.E.
University of Louisville—4, all.
University of Maine—4, M.E., Ch.E., E.E.
University of Maryland—4, M.E.
Mass. Institute of Technology—4, M.E.
McGill University—3, M.E.
Michigan College of Mining—4, Min. Eng.
Ecole Polytechnic de Montreal—4, C.E.
Newark College of Engineering—4, E.E., M.E., C.E., Ch.E.
University of New Brunswick—3, all.
University of New Hampshire—all.
New Mexico College—4, M.E.
New Mexico School of Mining—4, all courses.
New York University—2, E.E., C.E., 4, Ch.E.
University of North Carolina—4, all eng.
University of North Dakota—4, M.E.
University of Oklahoma—4, M.E., A.E.
University of Pennsylvania—4, M.E., 5, I.E.
Queen's Univ., Canada—4, all.
Rensselaer Poly. Inst.—4, C.E., M.E., E.E., Ch.E.
Rhode Island State College—4, all.

Rose Polytechnic Inst.—4, all.
Southern Methodist Univ.—4, all.
Agri. & Mech. College of Texas—4, M.E.
University of Toronto—4, C.E., M.E., Ch.E., E.E.
Tulane University—3, M.E., E.E., C.E., Arch.E., Ch.E.
Vanderbilt University—4, M.E.
University of Vermont—4, M.E.
Villanova College—3, all.
University of Virginia—5, M.E.
Washington University—3, Bus. and Admin.
University of Wisconsin—4, M.E.
University of Wyoming—3, M.E.
Yale University—4, C.E.

Example of Full Industrial Engineering Course Given in a Separate Department and With Its Own Degree

Curricula of Ohio State University

Outline of the First Year's Work of All Four-Year Curricula

In order to permit all students in the College of Engineering to have a year in which to find out definitely what courses they desire to pursue, the first year of all engineering curricula, except Architecture, is made uniform. While students are asked to indicate their choice on entering the College, they can change at the end of the first year without any inconvenience.

Autumn Quarter		*Winter Quarter*		*Spring Quarter*	
Mathematics (432) College Algebra	5	Mathematics (431) Plane Trigonometry	5	Mathematics (433) Analytic Geometry	5
Chemistry (401 or 411) Elementary or General	5	Chemistry (402 or 412) Elementary or General	5	Chemistry (403 or 413) Qualitative Analysis	5
Engr. Drawing (401) Principles of Engineering Drawing	4	Engr. Drawing (402) Principles of Engineering Drawing	4	Engr. Drawing (403) Descriptive Geometry	4
English (410)	3	English (411)	3	English (412)	3
Survey of Engineering Elements of Engineering	1	Survey of Engineering Elements of Engineering	1	Survey of Engineering Elements of Engineering	1
Military Science	1	Military Science	1	Physical Education	
Hygiene (400)	1	Physical Education (402)	1	Military Science (403)	1
Physical Education (401)	1				
Total	21	Total	20	Total	20

Note: All students should consult the curriculum of the department in which they are contemplating future work for further requirements. Especially is this necessary in the case of Summer Work required. The Departments of Chemical Engineering, Industrial Engineering, and Mechanical Engineering require summer work between the first and second years.

Industrial Engineering

Summer Quarter

Industrial Engineering Patternmaking	(411)	3
Industrial Engineering Forging and Heat Treating	(415)	3
Total		6

Second Year

Autumn Quarter			*Winter Quarter*			*Spring Quarter*		
Mathematics Calculus	(441)	5	Mathematics Calculus	(442)	5	Mathematics Calculus	(443)	5
Physics Mechanics	(431)	5	Physics Heat, Sound, and Light	(432)	5	Physics Electricity and Magnetism	(433)	5
Engr. Drawing Engineering Drawing	(421)	3	Engr. Drawing Machine Drawing	(422)	3	Mechanical Engr. Materials of Engineering	(427)	3
Industrial Engr. Metal Bench Work	(407)	2	Industrial Engr. Millwrighting	(408)	2	Industrial Engr. Elementary Mach. Work	(419)	3
Civil Engr. Elementary Surveying	(411)	3	Industrial Engr. Foundry Practice	(405)	3	Industrial Engr. Advanced Foundry Practice or	(406)	
Industrial Engr. Survey of Industrial Engineering	(401)	½	Industrial Engr. Survey of Industrial Engineering	(402)	½	Industrial Engr. Advanced Patternmaking or	(412)	2
Military Science		1	Military Science		1	Industrial Engr. Advanced Forging and Heat Treating	(417)	
						Industrial Engr. Survey of Industrial Engineering	(403)	½
						Military Science		1
Total		19½	Total		19½	Total		19½

Summer Quarter

Industrial Engineering Practical Experience in an Industrial Engineering Industry	(439)	5

Third Year

Autumn Quarter		*Winter Quarter*		*Spring Quarter*	
Mechanics (601) Statics	5	Mechanics (602) Strength of Materials	5	Mechanics (605) Strength of Materials	2
Industrial Engr. (601) Engineering Organization	4	Mechanical Engr. (507) Heat Engines	4	Mechanics (607) Dynamics and Hydraulics	3
Economics (403) Principles	3	Economics (404) Principles	3	Industrial Engr. (603) Work Analysis	3
Industrial Engr. (421) Advanced Machine Work	3	Industrial Engr. (623) Advanced Machine Work	3	Industrial Engr. (653) Work-Analysis Laboratory	2
Accounting (405) Outline of Accounting	5	Industrial Engr. (602) Laws of Engineering Management	3	Accounting (624) Factory Costs	5
				Industrial Engr. (630) Inspection Trip	2
				* Electives	3
Total	20	Total	18	Total	20

Summer Quarter

Industrial Engineering (639) Practical Experience in an Industrial Organization — 6

Fourth Year

Autumn Quarter		*Winter Quarter*		*Spring Quarter*	
† Electrical Engr. (630) Electrical Engineering	5	Electrical Engr. (635) Electrical Equipment	3	English (419) Advanced English for Engineers	3
Mechanical Engr. (513) Machine Design	5	Industrial Engr. (702) Work Routing	4	Industrial Engr. (703) Standardization and Simplification	3
Industrial Engr. (701) Selection of Manufacturing Equipment	3	Industrial Engr. (752) Work Routing: Laboratory	3	Industrial Engr. (705) Inspection and Waste Elimination	2
Industrial Engr. (751) Tools, Jigs and Fixtures	3	Mechanical Engr. (576) Laboratory	2	Mechanical Engr. (577) Laboratory	2
* Elective	3	*Elective	6	Industrial Engr. (730) Inspection Trip	2
				*Elective	8
Total	19	Total	18	Total	20

* For electives consult the chairman of the Department of Industrial Engineering, or see list appended.

† Students contemplating entering the electrical industry should schedule Electrical Engineering 775–776 in place of Electrical Engineering 630–635. The total number of hours required for graduation is 251½.

See announcement for detailed description of courses.

EXAMPLE OF FULL INDUSTRIAL ENGINEERING COURSE GIVEN AS A TECHNICAL OPTION FOR STUDENTS OF THE M.E. COURSE, AND WITHOUT ITS OWN DEGREE

Curricula of Purdue University

Freshman Year

First Semester		*Second Semester*	
(3)	Chemistry 1 or 1a	(3)	Chemistry 2 or 2a
(3)	English 1	(3)	English 10 or 19
(1)	Eng. Problems 1	(1)	Eng. Problems 2
(5)	Mathematics 1	(5)	Mathematics 2
(2)	Mech. Drawing 11	(2)	Mech. Drawing 12
(1⅔)	Military Training 1	(1⅔)	Military Training 2
(3)	Modern Language 21, 33, 41, 53, 61, or 73, or History 9	(3)	Modern Language 22, 34, 42, 54, 62, or 74, or History 10
(1)	Shop 32 or 33	(1)	Shop 32 or 33
(19⅔)		(19⅔)	

Sophomore Year

First Semester		*Second Semester*	
(2)	Descriptive Geom. 16	(4)	Applied Mechanics 1
(3)	English 14	(3)	English 31
(4)	Mathematics 3	(4)	Mathematics 4
(⅔)	M.E. Problems 90	(1⅓)	Military Training 4
(1⅓)	Military Training 3	(5)	Physics 22
(5)	Physics 21	(2)	Shop 34 or 35
(2)	Shop 34 or 35		
(18⅓)		(19⅔)	

Junior Year

First Semester		*Second Semester*	
(4)	Applied Mechanics 2	(3)	Economics 1
(3⅓)	Electrical Eng. 19	(3⅓)	Electrical Eng. 20
(4)	Machine Design 61	(4)	Machine Design 62
(⅔)	Testing Materials 31	(1)	Mechanical Lab. 70
(3)	Thermodynamics 30	(3)	Heat Engineering 31
(3)	Non-Technical Option	(3)	Non-Technical Option
		(3)	Technical Elective
(18⅓)		(20⅔)	

Senior Year

First Semester		*Second Semester*	
(1)	Hydraulic Lab. 49	(3)	Eng. Administration 103
(3)	Hydraulics 41	(2)	Industrial Eng. 124
(2)	Industrial Eng. 123	(1)	Mechanical Lab. 173
(2)	Mechanical Lab. 172	(3)	Technical Elective
(⅔)	M.E. Seminar 81	(3)	Non-Technical Option
(3)	Technical Elective	(2)	Cost Accounting 127
(3)	Non-Technical Option	(2)	Industrial Design 187
(2)	Time Studies 128	(2)	Thesis
(2)	Industrial Design 186		
(18⅔)		(18)	

See announcement for detailed description of courses.

Objectives and Curricula of the Industrial Engineering Department

Factors Influencing Curricula

While in the past many engineers were developed through individual pupilage rather than through schools, this number is now decreasing rapidly and at no time has had much influence on the educational program. The engineering school grew out of the arts college and its character has been shaped entirely by that academic background. In fact, the present curricula have changed but slightly in the past 50 years. At the same time there has been some diversity between schools to fit local needs and this has allowed some experimentation. Inasmuch as present engineering opportunities range over many levels of responsibility as well as over many fields of endeavor, we feel that some freedom from standardization is more necessary today than ever. There are certain lessons which engineers might draw from other professions but so far the latter have had little influence on engineering education. For instance, two or three years of liberal arts work prerequisite to engineering has not been popular on account of the time involved.

The Skeleton of Education

Most engineering educators agree that there is a skeleton of fundamentals which is common to all engineering. In fact, the tendency at present is to get back to these fundamentals rather than to divide further into more fields. On the two extremes one school offers about 40 fields of engineering and one school gives a single course regardless of individual interests. Most schools have five or six fields which we may call typical practice.* The differentiation for these fields is kept as far toward the upper end of the course as possible, that is, the freshman year is usually identical, the sophomore year either identical or nearly so, the junior year definitely in a single field but somewhat parallel as between fields, and the senior year perhaps entirely specialized and very little parallel as between departments.

In illustrating what was meant by fundamentals, the S. P. E. E. study listed the following:

(*a*) Mathematics, to include differential and integral calculus.
(*b*) Inorganic Chemistry, with laboratory.
(*c*) General Physics, with laboratory.
(*d*) English Composition, Speech and Literature.
(*e*) General Economics.
(*f*) Introduction to the Economics of Engineering.

* 83.5 per cent of all engineering students are enrolled in five fields and 70.0 per cent of all engineering students are enrolled in three fields.

(*g*) Introduction to the Law of Contracts.
(*h*) Drawing, and the Principles of Graphics.
(*i*) Technical Mechanics.
(*j*) Mechanics of Materials, with laboratory.
(*k*) Introduction to Hydraulics.
(*l*) Introduction to Heat Power Engineering, with laboratory.
(*m*) Introduction to Electrical Engineering, with laboratory.

Analysis of 18 Curricula

In studying the curricula of 18 Industrial Engineering departments, we have divided the fundamentals somewhat differently and have made a division between the fundamentals which belong to general engineering and those which more specifically have to do with management. Class hours were used rather than credit hours and differences due to a semester or term basis were avoided by weighting. The figures shown indicate the range of maximum-minimum semester hours, and the median for each group.*

TABLE 2

CURRICULA AND HOURS OF 18 INDUSTRIAL ENGINEERING COURSES
Fundamentals of Engineering

Group of Subjects	Range of Class Hours	Median of Class Hours	Notes
Physical and Mil. Tr.	0–22	6	
English	5–16	12	
Mathematics	4–20	16	
Pure Science	8–47	18	
Strength of Materials	0–14	5	
Drawing	0–35	12	
Mechanics	0–10	5	
Hydraulics	0– 6	3	If given at all
Heat-Power	0–16	6	
Elect. Power	0–13	8	
Survey	0–14	2	
Sch. Shop Practice	0–21	5	
Outside Practice	0–Coöp.	(2)	Summers supervised
Metallurgy	0– 5	2	If given at all
Engin. Problems	0– 9	2	
Electives	0–32	12	
Total for non-management		114	Or about 91 credit hours

* In groups where more than half of the 18 schools omitted a subject, the figure is not a true median but is a little below the median for the times which were given.

Fundamentals (?) of Management

Ind. Hist. and Econ.	2–17	6	
Methods and Processes	0–15	4	
Human Relations	0–16	6	
Production Control	0– 6	4	If given at all
Cost Control	0–16	7	
Statistics	0–10	3	If given at all
Marketing	0–12	6	If given at all
Finance	0–15	4	
Business Law	0–10	2	
Traffic Management	0– 3	2	If given at all
Ind. Mgt. and Org.	0– 6	3	
Total for management	(29% of whole course)	47	Or about 38 credit hours
Total for four years		161	Or about 129 credit hours
Average per semester		20	Or about 16 credit hours

Interpretation of Table

As will be seen from Table 2, the total median class hours for the non-management groups is 114. If we assume the ratio of all class hours to all credit hours to be 1.25, we obtain a total of 91 credit hours. A credit hour has been defined as a work load of three clock hours. The total class hours for the management group is 47, or about 38 credit hours, making a grand total over the four years of 161 class hours, or about 129 credit hours. This in turn gives 20 class hours per semester, or about 16 credit hours per semester.

The S. P. E. E. Report recommended that the total credit hours should not exceed 144, making the range of from 16 to 18 credit hours per week as a norm. The fact that the figures in this study are slightly below norm is due to our inability to classify certain miscellaneous subjects. Many of the schools had in their curricula courses which we must call freaks.* While local needs or traditions might justify these freaks, they are certainly not worthy of recommendation in general.

From this analysis we find that on the average, only a little over one-fourth of the time is given to the management group subjects,† that is, little more than in the few schools which segregate management work into the senior year. At the same time there is a

* As for instance Old Testament Literature.

† A small part of the electives can be taken in management subjects other than those required, thereby increasing this proportion to around one-third in some schools.

greater divergence of practice in this fourth of the work than is evident in the figures themselves. For instance, in the drawing group there seem to be two policies, one centering around 6 hours of drawing and one around 21 hours. Mathematics also shows two policies, one centering around 12 hours and one around 20 hours, with the majority scattered between.

Are These Groups All Fundamentals of Management?

Twelve of the 18 schools omit hydraulics and some of them omit surveying. This raises the question as to whether subjects considered fundamental for the older engineering fields are really fundamental to the newer field of Industrial Engineering. We do not contend with the general principle that industrial engineers should be bona fide engineers or that most of the fundamentals are essential to bring this about. Nevertheless we believe that these two subjects are certainly less fundamental to management, if they can be called fundamental at all. Personally, we would sacrifice them both to make way for management subjects. We would also apply the elective time entirely to management courses. If we now accept the median time for the fundamental groups, we will find that the time for management courses can be increased from the present average of 29 per cent of the whole, to 39 per cent, without increasing the total class hours. We only know of one precedent for this proportion, that of the newly proposed course at Cornell University, but believe that there is nothing unreasonable in the proposal.

Management Has Been Crowded Into Single Compound Courses

Although there is a certain inter-relationship between most management subjects, yet there is enough diversity among them to make separate functions in their practical application. For instance, plant layout, job standardization, financial incentives, etc., are applied by functionalized men and yet in school they are usually compounded into a single course for which a chapter or two of a single book must suffice. Not only is a general text book written by a single man certain to be superficial on some of these functions, but any one teacher is likely to be superficial on some of them. The practice of compounding is always necessary where the enrollment is extremely limited and this has been the case in most of the industrial engineering departments. No doubt some special subjects can be safely compounded provided the teachers use specially written texts in their preparation of each sub-division. Formerly there were few texts on the special functions so that the general text was the only thing possible. At the present time this condition is being removed by more thoroughgoing texts which represent the

best practice in each of the respective functions. In criticizing compounded courses we are thinking in terms of students who take a full industrial engineering course. The compounded course may be all that can be given to students taking the older engineering courses. In such cases it is far better to give a compound course than to give no management at all and if the instructor will familiarize himself with the special texts most of the trouble can be obviated. For the full I.E. course it is, however, better to avoid compounding altogether.

A Proposed Curriculum for Industrial Engineering

We maintain that there are subjects as much fundamental to management as those listed previously are fundamental to engineering as a whole, in fact it is surprising that this has been so generally overlooked. No doubt it has been due to the limited time allotted to management. Certainly the groups of management subjects given in Table 2 are not fundamental as named and completely omit some which are definitely fundamental. These fundamental groupings should be as follows: Industrial History, Economics, Psychology, Statistics, Accounting, and Management in General. Perhaps existing courses might be broken down to fit this classification, but as far as we can observe it will be necessary to break away from all existing programs in order to conform to these fundamentals adequately. Fortunately there are departments in most colleges for all of these true fundamentals except perhaps statistics, which has recently come into importance. If we now accept the fundamentals of general engineering * together with their median times as listed in the upper portion of Table 2, and add the fundamentals of management as outlined here, we will be able to construct a course, Table 3, which will be general throughout, and which will still have enough of fundamental engineering to justify an engineering degree.

We may say that management in general should embrace all fields of application such as factories, public utilities, transportation, mines, and possibly agriculture. This program would be made up of 102 class hours of fundamentals of engineering, plus 65 class hours of fundamentals in management. On the credit hour basis, this would mean about 17 credit hours per semester, which is within the normal range. Two of these, employment and purchasing, although belonging to the sequence of courses are partially in the nature of specializations and might well be elective. We would also add four two-hour electives as follows: Business Law, Marketing, Finance and Sociology. A few schools consider these latter subjects of prime importance to all industrial engineers, but they are definitely within the business school scope and while we

* Except Hydraulics and Surveying which we would offer as electives.

think they should be offered, we do not think an industrial engineering faculty is usually equipped to give them well. At best, we believe, they represent minority needs and should not be required of the majority.

TABLE 3

CURRICULA AND HOURS FOR PROPOSED I.E. COURSE

	Class Hours	
Fundamentals of Engineering		
As shown in Table 2		
Except electives	102	
(might save 2 hours more by making hydraulics elective with surveying.)		
Fundamentals of Management, With Subdivisions		
Industrial History	3	
Economics		
Theory	3	
Applied	4	
Psychology		
Theory	2	
Adaptability tests (lab.)	3	
Employment	2	elective (below)
Welfare	3	
Organization and Coördination	2	
Statistics		
Theory	2	
Laboratory	3	
Accounting		
Bookkeeping	2	
Cost Analysis	4	
Budgetary Control	3	
Management of Factories, Public Utilities, Transportation, Mines, Construction (and possibly agriculture)		
Processes and Material Handling	3	
Job Standardization (lecture)	3	
Job Standardization (lab.)	3	
Incentives	3	
Production Control	4	
Quality Control	2	
Purchasing—Storing	2	elective (below)
Equipment, Jigs and Tools (1 hr. Lect., 2 hr. Draw.)	3	
Plant location, const. and Maintenance (lect.)	3	
Plant layout (drawing)	3	
Total for Management (39 per cent of whole course)	65	or about 52 cr. hrs.
Total for four years	167	or about 134 cr. hrs.
Average per semester	21	or about 17 cr. hrs.
Electives in Place of Two Above		
Business Law	2	(in place of two above together with Surveying and Hydraulics.)
Marketing	2	
Finance	2	
Sociology	2	

Arrangement of Courses

We do not attempt to suggest how these courses should be distributed through the four years other than to point out that the last group, headed Management, is more subject to special application than the others, so that as much of that as is feasible should be left to the Senior year. On the other hand, applied economics, organization and budgetary control are also most appreciated if given in the senior year after the student has had some good outside experience. There are certain prerequisites which would influence the year also. These are mostly within each major group.

While we are not attempting to write detailed course descriptions for each course listed, we will rapidly mention each, in order to elucidate our conception.

Industrial History.—Industrial History would be primarily the usual course for the country involved, although it should not ignore the outstanding points in the industrial history of other countries. Its primary purpose is to give perspective to the student. Secondarily it should be so presented as to teach him the historical method.

Economics.—The theory of Economics should be a broad treatment of economic law and of the more important theories pertaining to the field. No great emphasis should be given to applied problems, as they can be included in the second course.

Applied Economics. In the first half of this course the cost of living, wages and prices should be studied together with the history of business cycles. It should depict the various trends leading to the best known measures for economic stability. In the second half, such economic formulae as those now available for lot sizes, replacement of equipment, and justifiable expenditure for purchasing, should be presented.

Psychology.—The theory of psychology would be primarily a course in nomenclature, preparing a student to interpret behavior in terms of the psychologist.

Adaptability Tests.—This would be laboratory work in the best practice of recognizing and measuring intelligence, skill and suitability for vocations and jobs. This is prerequisite to "Employment."

Employment.—This would describe not only the technic of hiring and firing, but would include job analysis, job classification, rate setting, follow-up methods and labor turnover.

Welfare.—This would include the best practice in accident compensation, employment insurance, pensions, stock ownership, housing, the prevention of accidents, first aid, etc.

Organization and Coördination.—This would be a study of the types of organization, the means of defining responsibility, the

various routines for giving orders and receiving reports, together with the best practice in coördinating departments both by personal leadership and by committee leadership.

Statistics.—The theory of statistics would be the usual course in the statistical study of data. The laboratory would be made up entirely of illustrative problems typifying a wide variety of applications.

Bookkeeping.—This would be a simple course in the elements of keeping ordinary accounts.

Cost Analysis.—This would be the study of cost data with a view to interpreting them and to allotting indirect expense correctly.

Budgetary Control.—This would include the composition of both factory and administrative budgets, together with their use as instruments of control.

Processes and Material Handling.—This course would go into the problem of proper scale for production. Process charts would be used to illustrate the various ways of subdividing a departmental job. Typical processes would be studied, preferably through inspection visits to factories. This course should be prerequisite to all of the others in the manufacturing group.

Job Standardization.—So far as the lecture is concerned Job Standardization should cover the history and principles of job improvement both by the stopwatch and the micromotion methods. It has been found best to give this in the first semester and the laboratory the second semester. The laboratory should give actual practice in making a preliminary survey, analyzing motion paths, improving the work place, synthesizing the best elements of work, writing up the study, making instruction sheets, and finally applying the standard. This should be prerequisite to incentives.

Incentives.—This course should include all non-financial and financial incentive plans. It should summarize wage theories briefly and then carry through the mathematical analysis and design of plans suitable for all kinds of applications, including group applications. It should so stress principles and limits that experience from the factory may be applied in modified form to the newer fields such as the drafting room, office, salesmanship, etc. A brief study of training for task should also be included.

Production Control.—This would cover the technic of planning, that is, of routing, scheduling and dispatching as applied to both highly centralized and essentially decentralized types of control.

Quality.—This would cover standards and specifications for quality and the many principles of inspection. This course should be prerequisite to purchasing and storing.

Purchasing—Storing.—The first half of this course would in-

clude the economic and the physical aspects of purchasing both materials and equipment. The second half of the course would cover the principles of storing, and stores control.

Equipment, Jigs and Tools.—This course should give a rapid survey of machine shop equipment, with special emphasis on modern tooling and jigs, together with their economic considerations. The last portion of the course might include briefly other major industries. The drawing part of the course should illustrate principles by designing some simple jig or fixture for actual use, perhaps in coöperation with the job standardization laboratory. This should be prerequisite to the following.

Plant Location, Construction and Maintenance.—This course would cover the problem of selecting the best location for typical sets of conditions. The various types of construction would be studied for suitability to use. The maintenance of buildings and equipment should also be included.

Plant Layout.—This is primarily a drawing course and should lead to the making of floor plans, the locating of equipment, conveyors, etc., for given cases. These last two courses should be given simultaneously.

The Present Problems and Proposed Solutions

Differences Between the Two Types of Schools

The evidence is conclusive that many graduates of both business schools and industrial engineering departments are able to climb to the very highest positions from these separate starting points. In neither case can the men progress far without getting into human problems, coördinating different members of an organization, influencing plans and policies and ultimately making major decisions. As in all work, the numbers of men are bound to decrease as the advancement proceeds. The business school man has a slight advantage in that he is familiar with law and banking. The lawyer and the banker have frequently headed companies, and business school men are likely to benefit by having some of their qualifications. On the other hand the engineer can get down to the bottom of problems and can frequently excel in the matter or organization. Commonly the deciding factor between the two is personality. Certainly men of each training are needed in any large industry. Between the extreme paths of promotion there is a twilight zone where both business school men and industrial engineering men are likely to be found. Most common in this respect is the accounting field. For this reason we think that thorough courses in accounting should be given by both schools and that there is nothing to be feared from this overlapping. Purchasing positions are filled from both schools.

Where the company processes are extremely technical the engineer may have the advantage, otherwise not. Personnel positions are filled from both schools. Here we feel certain that training has less to do with the matter than personality.

Since the business school can accept applicants more readily who are less prepared in mathematics and science, we believe that they should be careful in selecting their freshmen and not take them if they are dodging the work involved in such subjects. At the same time engineering schools may have many applicants who, prone to technical detail, may be deficient in personality. The latter schools should therefore take pains to select only those who show evidence of personality or evidence that it can be developed.

Similarities Between the Two Types of Schools

In the first place both schools have at bottom a similar set of purposes which are as follows:

1. To formulate the principles of an emerging profession,
2. To prepare more adequately many men who are to enter these professions,
3. To accomplish the above without setting up narrowly specialized courses;
4. In many cases the same employers are hiring men from both schools. These employers realize that the present diversity of industry makes it impossible for either course to go far into any particular application. In fact employers are prepared to give all graduates from six months to two years of "cadet" training when they first enter employment. Employers do not therefore expect graduates of either school to know much about their peculiar problems, but they do expect these men to be trained in fundamental principles and to be able eventually to influence the behavior of other men. Employers expect men from either school to be able to use the scientific method as a tool and in so doing to be aware of the social, economic and public aspects of business problems.

Both schools are putting mental discipline above mere information and are attempting to develop sound and broad thinking so far as the maturity of the students permits. The following comment of Dean Hotchkiss, representing the best thought among business school educators, might equally well represent the best thought among engineering educators. "Business education must be considered not as a thing in itself, but as a part of the whole scheme of higher education. Schools must have a professional aim and furnish a basic mental discipline and a broad outlook regarding the principles of business."

An Important Link Between School and Industry

The Coöperative Plan, originated by Herman Schneider at the University of Cincinnati in 1906, has made some progress, but has been utilized by only seven of the 35 schools giving Industrial engineering, and by only five business colleges. Space does not allow an adequate discussion of this issue, but we believe it deserves a brief comment. Both the idea of rating shop experience on a par with collegiate courses, and that of interrupting continuous study, have seemed so radical to most faculties that this plan has not extended rapidly. The S. P. E. E. Report, which has been exceedingly influential, failed to give this matter much recommendation. On the other hand this same report did conclude that the Coöperative Plan was particularly helpful to the graduate who entered the operating side of industry. This conclusion, when considered in connection with the fact already brought out that two out of every three engineering graduates find themselves in management work after 15 years, should have given the Coöperative Plan significance at least for Industrial Engineering. It seems strange that the investigating committee did not relate these two portions of the same general investigation.

The fact is that it is difficult to teach any management subject to men who are wholly inexperienced in industry. It is utterly impossible to *teach human nature* and it is next to impossible to depict any management project completely in the classroom. Certainly the success of those industrial engineering students who have had coöperative experience is sufficiently distinct to merit a greater use of this plan.*

Various Views of Employers

One point of view expressed by a prominent employer indicates an advantage to the business school, and at the same time challenges the engineering school. It is claimed that the engineer develops such reliance upon his formulas and rigid scientific facts that he is unable to modify his conclusions when dealing with practical and complex situations. Moreover he is frequently isolated in his early work. As a result, he is inflexible and prone to be antagonistic. Personally, we feel that this goes back to some deficiency in the student, teacher or employer rather than to the nature of engineering itself. We concede that there is some basis for it but we do not think it representative of engineering as a whole nor irreparable where it does exist. It is undoubtedly true that some engineers, both in industry and on faculties are lacking in liberal

* See Proceedings of the Assoc. of Coöp. Colleges available from this writer.

education, but again we are certain that only a minority are so deficient.

One point of view, which is a challenge to the business school, claims that the engineer has accomplished his technical work if anything too well, that the physical sciences have forged ahead of the social sciences, and that what we need now is ability to coordinate all resources and all individuals to the purpose of gaining better balance and stabilization. In this connection it has been suggested that the school of business is peculiarly suited to develop men who will be able to cope with this broader problem, and incidentally to do for distribution what the engineering school has already done for production.

In order to represent viewpoints from factories, railroads and public utilities we venture to present a few brief quotations.*

The school has properly performed its function when it has carefully selected its individuals and has put them in the way of an understanding of the objectives, given a training that will develop their intellectual functions toward the obtaining of these objectives. In other words, familiarizing the undergraduate with the means of work, imbuing him with the habits of work, along with a realization that when he receives his diploma he can only consider that as his matriculation certificate in the school of affairs, where, with what he has absorbed in all his previous training, he will have to work out his own results. (F. A. Merrick, President, Westinghouse Electric & Mfg. Company.)

As I see it, the technical school should train young men to become clear and logical thinkers, controlled by common sense, and to attain the capacity for exactness of method, correct analysis, and educate them in the fundamental principles of natural laws and economics and their application to human requirements, to face the facts in any situation and be guided by them; to write and speak clearly and correctly, and to develop that character and integrity without which all other education is lost. (L. W. Baldwin, President, Missouri Pacific Lines.)

Utilities want technical graduates who aren't all technical. They want men with imagination and the ability to learn and think. Men with a background and education broad enough so that technical training assumes its proper place but does not become the whole. The electric utilities need such men and constantly will need more of them. (M. S. Sloan, President, the New York Edison Company.)

We have only become a technical industry within the last decade. Ninety per cent of that technicality has to do with production engineering; less than ten per cent with physical research and development. The advancement in these departments has been in direct proportion to the engineering effort; I mean by that our productive facilities excel those of design and distribution, and when I think of the great things that are rapidly coming forward, the need for these college men is urgent. (A. R. Glancy, President, Oakland Motor Car Company.)

* Proceedings of the Dedication of the J. W. Packard Laboratory of Electrical and Mechanical Engineering, Lehigh University.

The development of our physical sciences is more rapid than our social sciences and so it is especially important that from now on we have in the field of business men broadly educated in economics and politics as well as men trained in the technical detail of business machinery. (Owen D. Young, General Electric Company.)

Management Seems Remote to Undergraduate

Undergraduates are unappreciative of the scope and importance of management. Those in the engineering college usually enroll with technical interests and those in the business college scarcely know what it is all about. Only when they begin to face the problem of a job or perhaps not until they have been assigned a subordinate place in management do they awake to the significance of these things. It is notorious that only a few of any class know for what kind of work they are suited, even at graduation.

The Graduate Has an Awakening

Soon after graduation most young men go through a veritable mental revolution. They grasp at the few straws of industrial subjects which they have had, subscribe to trade magazines, take up night school, and in various ways try to get what they formerly disdained.

In a questionnaire sent out by the S. P. E. E. Committee asking what were considered the more important omissions from college courses, over half of the replies from the younger graduates cited economics, business and commercial subjects as the most serious ones. 90.6 per cent of the recent graduates stated that they were not as well qualified to deal with economic elements as with technical elements of their engineering problems. 69 per cent of the graduates of five or more years experience entered a similar complaint.

The same survey lists subjects studied by college trained men since graduation. These men were employed in six different industries. Some of these subjects came from narrow fields in which the men found themselves employed, but by far the larger number were in the field of business.*

Similarly it was asked what subjects they regretted missing in college. Seven of these subjects and the number mentioning them are as follows:

Business Administration	456
Economics	226
Accounting	179
Psychology	122
Salesmanship and Advertising	118
Industrial Management	104
Production and Production Methods	33

* This list was nearly identical to the one shown.

Later Appreciation of Management Should Be Our Guide

On the matter of pre-graduation experience, the majority of these same graduates stressed the desirability of utilizing their summers for experience. This late appreciation of management is so emphatic that we are surprised that more was not made of it by the S. P. E. E. It is claimed that engineers have done well in management anyway and that any sizable shift in curricula might produce poorer rather than better results. We can only point out that the men have overcome the deficiency by night school work and private study, which we believe might better be put upon diverse engineering subjects as needed by the minority rather than upon management subjects which are needed by the majority.

More Radical Changes Needed

Bossard and Dewhurst, speaking for the Business School, say that "coördination of the general and business subjects into a curriculum conceived and planned as a whole seems to be a major need at this time in collegiate education for business." On this point the business schools are no worse off than the Industrial Engineering departments. In the first place, such subjects as economics and psychology have usually been taught by members of the liberal arts faculty. Under these conditions, courses have frequently failed to give the business school student or the engineering student the kind of courses that could be used as tools in their future work. The typical economist or psychologist seems to go at it as though he were trying to make every member of his class a professional economist or a psychologist. Furthermore, the time has often been so short that courses barely emerge from the introductory stage.

It is not that we criticize the aim of the liberal arts college. As a matter of fact we think that the professional schools would do well to incorporate more of that aim. The important thing is not so much the factual content of any course as the disciplinary value of the course. But we believe with L. C. Marshall, former dean at the University of Chicago, that cultural values are better obtained through the effective teaching of fundamental courses than through any set of courses which may have been classified as cultural. W. E. Hotchkiss, Dean of the Stanford Graduate School of Business, states this aptly by saying that "Any course, no matter how direct may be its practical application to life, is cultural, if it is taught and studied in such a way as to develop a student's mental power and to build up his personality. Any course so taught and so studied is practical, no matter how indirect its application may be." *

* Proceedings of the Stanford Conference on Business Education, Stanford University Press, 1926.

In brief, this depends to a large extent upon a teacher and it has not been easy to secure good teachers for all the subjects involved in management courses. The fact that business school educators are more concerned about this mental discipline than about course content, is encouraging. They seem to agree that the historical method to be used in discovering the truth is fully as important as the knowledge and perspective of history itself; that the power of straight thinking, the formation of positive work habits; the ability to interpret and relate facts to new problems, is after all the most important as well as the most difficult problem for the school.

We Must Make More of Science and Principle

We have pointed out elsewhere that the business college suffers for want of more scientific foundation. The few basic subjects such as economics, and psychology, although partially scientific, are certainly not so wholly scientific as are the physical sciences underlying engineering. On the other hand there is a rapidly growing wealth of principle throughout the realm of management which can be stressed and made generally applicable. The difficulty is to transmit abstract principles without losing their significance. General R. I. Rees of the American Telephone and Telegraph Company, has explained this difficulty by saying that the human mind can only capture and retain a principle by putting it "in solution" with some actual case and that, when a different application of the principle is needed, it is not easy to withdraw the principle from the temporary "solvent."

The Management Laboratory

Various means are being tried to transmit these principles of management. On the engineering side some schools combine the trade work, such as machine operating, with a course in planning and dispatching or a course in stop-watch "time study." The students devise their own forms and procedure. In this way they learn at first hand what will work effectively and what will not. Doubtless this has some value but with the meagerness of time available for management courses it seems to us that there are other matters upon which laboratory time can be used more effectively. The Gilbreth Micromotion Method, for instance, involves a great deal in the way of principle, and also what the Gilbreths called "super-standards" of work. No one, including our teachers, has ever appreciated this by merely reading about it, and yet New York University is the only one which has attempted to give a thorough-going laboratory course in micromotion. It has been

doing this for three years under the able leadership of Professors J. W. Roe and D. B. Porter, and we feel that we are still a long way from catching up with the Gilbreths. We see infinite possibilities for research in this work. This is of course only one of the many unexploited functions. The point we wish to make is that we will gain more in the way of scientific discipline by using our time on the most difficult problems than by using it on the more simple problems such as routine, in which there is a very small amount of principle at best. Furthermore, by using laboratory time for real experimentation we will raise Industrial Engineering to the same status as the older engineering courses. The business schools attempt to teach the laboratory method through problems in statistics, accounts and case studies drawn direct from business, or through their Bureaus of Business Research. This is about all they can undertake in the way of laboratories, unless, as Henry S. Dennison has suggested, companies can give over real problems to them from time to time and allow the students to come into the plant long enough to get the full setting of the problems. Where physical control constitutes the minority and human control the majority of any problem, life itself has always been the best teacher and the more we can draw upon life situations for our Management laboratories the better we will succeed. Some form of coöperation between school and industry offers therefore the best solution for many problems.

In undergraduate work we can not go far in giving students experience but we can train them to learn from experience. We can not train much in leadership but we can train well for leadership. We can not graduate managers but we can more definitely prepare minds for management.

CORRECTION OF MALADJUSTMENTS TO GROUNDING COURSES IN ENGINEERING DRAWING

By S. F. CLEARY

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During the earlier and more leisurely era of engineering education, grounding work in drawing was customarily provided by means of three successive courses. The initial course was non-technical in nature, its purpose being simply that of acquainting the student with the use of drafting room equipment and with the execution of the manual tasks of drawing. The second course, descriptive geometry, added the theory of graphic representation. Shop work, accompanying these two courses, introduced technology of construction. When the third course was started, the student was prepared in the prerequisites of technical drawing; namely, the elements of drawing and general technology of construction. This third course was introductory to the technical drawing of the times. It was rarely completed before the end of the sophomore year and in many instances it ran well into the junior year.

With the development of the engineering professions the leisure of the early days was gradually absorbed by the increasing content of the course of studies. The bulk of these increases was naturally concerned with the post-grounding or secondary stage of the course. More and more time was allotted to this stage of study. Much of this time was obtained by decreasing work in manual skill but eventually the grounding stage of certain lines of study had to be shortened in order to provide additional time and to permit proper sequencing of the secondary work.

It was at this point in the development of engineering education that the methods of presenting grounding courses in drawing began to deviate from the policy dictated by rational analysis. The deviation was not so rapid as to be apparent. It occurred in gradual steps as the need of minor adjustment was encountered. In most colleges, the original system of grounding was finally replaced by one or the other of the two systems which are now in common use. The more popular of these two systems was formed by shifting work from the third to the first of the three original courses, until but two courses of truly grounding nature remained. The less popular but more rational system resulted from a combination of the second and third of the three original courses.

The Initial Technical Course System

Under the more widely used of these two systems, the initial course, regardless of its title or avowed purpose, is compelled to provide instruction in the elements of drawing prerequisite to technical drawing; namely, the use of drafting room equipment, lettering, delineation, and the theory of graphic representation. In addition to these primary functions the course is forced to provide some instruction in general technology of construction before the ultimate task of offering instruction in technical drawing may be started. The accomplishment of these combined tasks is obviously impossible within the usual available time and the inevitable result is inadequate grounding in both the requisite elements of drawing and in technical drawing.

The course does not and cannot meet the combined functions of the initial and third courses of the original system. In its present form it merely offers drill in the execution of the combined manual tasks of the two original courses. The students execute, by direct copy methods or with the assistance of explicit instructions, an imposing array of drawings. Unfortunately these drawings are as unintelligible to their makers as the kinematic drawings executed by students in those high school courses which have outdone their blind leader.

Descriptive geometry, the second and final course in this system of grounding, comes as an anti-climax. It seems purposeless to the student; doubtlessly, because it is presented too late to serve as an efficient unit in the chain of instruction.

The Combined Descriptive Geometry-Technical Drawing System

Under the less popular modern system, that in which technical drawing is combined with descriptive geometry, the results obtained are somewhat better, because the student is enabled to grasp the application of the theory of graphic representation to drawing. However, neither descriptive geometry nor introductory technical drawing can be presented as efficiently as is possible in separate, sequenced courses.

The unsurmountable objection to this system is the fact that it is unsuited to instruction in that division of technical drawing of which the student is prepared to make a study, namely working drawing. This objection does not arise wholly from the impossibility of doing justice to both descriptive geometry and working drawing within the available time; it is based mainly upon the fact that the two subjects are of incompatible natures. The innumerable departures from true and complete graphic representation prac-

ticed in the construction of working drawing pictures makes this division of drawing unsuited for use as an example when teaching the principles of descriptive geometry. The treatment of working drawing under this system is therefore unavoidably inadequate and design drawings, beyond the development of the student, are assigned because they offer tempting examples of the application of the exact science of graphic representation.

This system of grounding, unlike the more popular system, has a rational basis because it was reasonably feasible, during the early days of engineering education, to combine the functions of the second and third of the three original grounding courses. If technical drawing were still in the undeveloped state of earlier days, this system would be satisfactory.

The Missing System

The reason why the third possible rearrangement of the original system of grounding in drawing was not attempted, is not clearly in evidence. Under this third scheme an initial course would have been offered which combined the functions of the first and second of the original three courses. The second and final course of this missing system would have been introductory to the technical drawing of the day.

Such a rearrangement would have been wholly rational, because it would have provided instruction in the requisite elements of drawing and allowed time for instruction in basic technology before offering the introductory course in technical drawing. If a system, based upon this rearrangement of the original scheme, had been developed, in pace with the development of the engineering professions, it would not only have provided adequate grounding courses in drawing, throughout the changing times, but it would have been instrumental in the development of both working drawing and basic technology of construction as teachable subjects.

How the Maladjustments Have Been Corrected for Mechanical Engineering Courses

The situation brought about by the maladjustment of the early system of grounding has been corrected for mechanical engineering courses by a virtual reconstruction of the missing third system.

The first step in this work was the recognition of working drawing as the logical division of technical drawing for introductory study. This recognition was made possible by a comprehensive functional analysis of technical drawing which isolated working drawing from the entangling influences of design drawing, graphic representation, geometry, the technique of draftsmanship, etc. The

isolation of working drawing facilitated a further analysis of the elements of the subject. The formulation of basic principles eventually enabled a rational classification of the mass of heterogeneous rules and conventional practices which have been accumulating in classroom and commercial drafting room since the application of technology first began to establish the identity of design as distinct from that of construction. Perhaps the most important original contribution to the subject was the formulation of the theory of dimensioning, although the classification of departures from true and complete representation and the theory of view selection are noteworthy and sorely needed additions.

The task of arranging the subject matter for the initial course, the purpose of which is to provide instruction in the requisite elements of drawing, at first appeared to be a simple matter. However, a survey of texts on descriptive geometry failed to reveal one designed expressly for the purposes of instruction in the principles of graphic representation as employed in technical drawing. An investigation of the requirements to be met by a suitable text brought to light several essential features not incorporated in the available works and prompted the preparation of a new treatment of the subject.

The classification of subject matter for arrangement in the new text was based upon the application of graphic representation to technical drawing. Graphic description was given initial and individual attention, followed by a treatment of graphic computation. In the development of the principles of graphic description it was found desirable to lay special emphasis upon the point as the unit of graphic description and upon the use of this unit in the determining data of both given and required lines, planes, plane figures and solids. It was also necessary to expand the basic principles of graphic description in order to enable the student readily to apply these principles to pairs of reference planes in addition to the primary pair. This was deemed essential to basic training in the type of graphic representation prerequisite to technical drawing. Special care was taken to avoid certain methods of presenting the subject matter which have grown popular during the period in which descriptive geometry has been offered as the second course in the grounding system. The solution of problems was not relied upon as the sole means of presenting the subject and abbreviated solutions which fail to demonstrate the application of basic principles were avoided. Highly organized pedagogism was also avoided because of the tendency of beginning students to learn a course rather than strive for an understanding of the subject.

Advantages of the Corrected System

It is generally agreed that the degree of educational maturity which may be held as the goal of a course of engineering studies, depends to a very great extent upon the provisions made in the course for early grounding in those subjects which are essential to the pursuance of engineering learning. It is also generally agreed that the fields of student endeavor grow more fertile as the post-grounding stage of the course progresses, because learning grows more accessible as knowledge is expanded.

An unnecessary postponement or prolongation of the grounding stage has a disastrous effect upon the degree of educational maturity which may be held as the goal of an engineering course because late grounding automatically disqualifies the student from effort in the most fertile fields of study. Inadequate grounding has much the same result because it retards all subsequent study in related subjects.

By eliminating all tendency toward unnecessary postponement and prolongation of grounding work in drawing, the corrected system assists in providing a maximum of accessibility to learning in those fields of study to which a knowledge of drawing is prerequisite.

The corrected system is the only method of providing adequate grounding in engineering drawing, because it alone offers adequate instruction in introductory technical drawing. When properly supported by courses in introductory technology of construction, the new working drawing course of this system is capable of relieving design courses from their present time-taking and depressing burden of completing grounding work in drawing.

The fact that the creation of the new working drawing course has called attention to a neglect of duty in providing adequate grounding in modern engineering technology, is in itself an important contribution toward increasing the general efficiency of engineering education. The effectiveness of all design and industrial courses will be improved when this duty is properly met, because design and industrial courses will be relieved of their present awkward task of teaching basic technology and because students will be better prepared to receive instruction in design and industrial subjects.

In the creation of the corrected system of grounding, working drawing has been freed from confusion with its prerequisite subjects such as lettering, draftsmanship, geometry, graphic representation, etc., and has been established as a subject equally as technical as the divisions of engineering work it serves, namely design and construction. As a result of this definition, it is now apparent that working drawing, design and construction all differ

in the same order and to the same degree in their application to the different technical divisions of engineering. This technical association of working drawing with design and construction should settle all controversy in respect to the feasibility of offering common grounding in drawing to students of different branches of engineering. Under the corrected system the initial course in the requisite elements of drawing shall obviously be capable of serving all branches of engineering. The second course, however, being technical in nature, can serve only those branches of engineering in which it is possible to have common courses in design and construction.

ENGINEERS, MANAGERS AND ENGINEERING EDUCATION *

A Discussion of the Educational Problems Raised by the Recent Occupational Surveys

By

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AND

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(The following article is submitted by the Committee on Instruction in Industrial Relations as a report to be read at the Annual Convention. The Committee hopes that it will be discussed. Forces are at work which may cause significant changes in industry—and influence engineering education. Managers in industry and in education must face these problems. R. L. Sackett, Chairman.)

Engineering education is an important pathway to executive responsibilities. Three-fifths of all engineers who live a normal life span, spend over half their working lives in technical or general administrative work.[a] Over half of those in administrative posts in industry spend most of their working lives in general management. The demand for engineers in administrative positions is so great that these positions offer engineers remuneration considerably greater than that offered for engineering work which does not involve some responsibility for the management either of men or of affairs.

This situation was first indicated by a survey made by the Society for the Promotion of Engineering Education in 1924.[1] This survey covered the work and earnings of 5,000 engineering graduates.

* To be presented at the 40th Annual Meeting of the Society at Corvallis, Ore., June 29–July 1, 1932.

[a] Throughout this article the word *administrative* is used functionally to designate any position, however minor, of which management of others is a substantial part. It thus refers as much to such subordinate positions as foremen or supervisor of a drafting or experimental room as to major administrative positions.

[1] See S. P. E. E. Report of the Investigation of 1923–29, pp. 228–238.

Later less extensive surveys gave general support to the S. P. E. E. figures. Last fall, the American Society of Mechanical Engineers published the results of a second extensive survey. This survey covered the work and earnings in 1930 of 9,000 mechanical engineers [2]—over half of the membership of the Society. It gave almost identical results on all common points with the S. P. E. E. survey. The fact that the results have remained constant over a period of seven years gives them added weight.

The drift of engineering graduates from purely technical to partly or wholly administrative duties that was shown by the S. P. E. E. survey, is shown in greater detail by the A. S. M. E. survey. In the first five years of practice only one sixth of mechanical engineers attain posts involving any administrative duties. With each year of age a larger proportion assumes some administrative responsibilities, because progress even in strictly technical work usually involves the management of others. By 40 years of age three fifths are in positions involving administration. Then the drift stops. Apparently, the two fifths who do not attain positions of executive leadership by 40 rarely do so at all.

Among those engineers holding administrative positions in industry, there is a secondary drift from positions of technical management to those of general management. During the first years after graduation, but a quarter of the engineers in administrative positions are in general management. This proportion, however, steadily increases as engineers grow older, until at 40 years of age it is over half, and after 55 almost three fourths of the total number of engineers in industrial administrative work.

To an astonishing extent the greatest demand for engineers, as indicated by the remuneration offered, is in wholly or partly executive rather than exclusively technical work. This is best seen in a comparison of median salaries, since median salaries are generally accepted as the best indication of the pay of the typical man. The median earnings of non-administrative engineers do not exceed $5,000 at any age. The median salary of the engineer in work involving administration passes $5,000 at 35 years of age and reaches $9,500 at 55. That of the engineer in general managerial work exceeds $6,500 at 35 and reaches $12,000 at 55.

That experienced engineers recognize the executive aspects of engineering work and the consequent importance to engineering success of the capacity to deal with and manage men, was clearly indicated in the S. P. E. E. survey. This survey secured the opinions of older graduates on "the qualities which they seek in younger engineers whom they employ and on the results of engineering

[2] See "1930 Earnings of Mechanical Engineers"—reprinted from Sept., Nov. and Dec., 1931 issues of *Mechanical Engineering*.

courses." Among these qualities, "good character and qualities of leadership" received by far the highest rating. On the other hand, these same two qualities came last in rating the qualities developed in engineering courses.[3] Similarly, the 1,500 engineers who replied in writing to the question "What are the most important factors in determining probable success or failure in engineering?" asked by the Carnegie Foundation for the Advancement of Teaching, mentioned personal qualities seven times as frequently as they mentioned knowledge of engineering science or technique of practice.

In 1928, at a conference of Deans of Engineering Schools, Owen Young said "Technical concerns frequently have to appoint men without technical training to their chief administrative posts because of the tendency of the man working on scientific problems to get too specialized a point of view at the expense of a general capacity to organize or 'command' large projects," and added "industry itself often deepens this purely scientific interest by assigning the engineering graduate to routine technical work."[4] At the same conference, Mr. O. H. Cheney, Vice President of American Exchange Irving Trust Bank, said "Real knowledge of sound management principles as applied to personnel relations must be a part of every executive's equipment . . . it isn't merely a matter of being human, it is a problem of being intelligently human. No man is born that way. . . ."[5] And Mr. S. A. Lewisohn stated: "Of course, we all hear it said 'Well, the ability to manage men is a matter of innate biological traits. . . .' But the difficulty is that those traits are of no value to anyone unless they are developed."[6]

Thus the evidence presents a rather clear picture of the problem before engineering schools. *A predominantly executive profession both in the occupations of its members and in its rewards; a training that with all its merits, in the opinion of its graduates has been least effective in developing the qualities of leadership which underlie executive success; and a growing body of opinion that executive traits can be developed by training.*

Of course, engineering has become an executive profession on the basis of an exclusively technical training, which until recently rarely deviated from its course even to touch upon the problem of managing men. But until recently there was no other training for administrative work, while today schools of business administration of high quality abound. Moreover the recent statistical

[3] See S. P. E. E. Report, supra, p. 239.

[4] See "The Teaching of Labor Relations in Engineering Schools." 1928. Published by Mr. S. A. Lewisohn, pp. 63–64.

[5] See "The Teaching of Labor Relations," supra, p. 19.

[6] See "The Teaching of Labor Relations," supra, p. 9.

study conducted by the Engineering Foundation of data concerning the earnings and occupations in 1928 of 31,000 graduates of Land Grant Colleges indicates that as between the relative earnings in business of engineering graduates and of arts and science graduates, "the advantage appears to lie rather strikingly with the arts and science group."[7]

The difficulties in meeting this situation and in securing the opportunities which it offers to engineering students are obvious and real. The engineering curriculum is already overcrowded. To teach the fundamentals of management thoroughly is almost to attempt to teach an entirely distinct profession. To teach the management of men requires developing new methods and embarking in a new field. Under these circumstances it is impossible to speak categorically. The solution, however, would seem to lie along two main lines.

Many, perhaps most men who come to engineering schools, plan to be technical engineers. Although a majority of them later achieve administrative duties, they do so because of technical attainment. Moreover they usually assume administrative responsibilities in technical fields where administration is engineering. For such men, engineering education must remain highly technical. Yet for such men some instruction should be provided to give them a background of industrial relations experience and principles, and a method of approach to problems of human management. For they must be so prepared that they will learn from experience to deal with human relations in spite of the tendency of industry to start them in work with the minimum of human contact.[8]

Other men—and as their needs are more specifically recognized by engineering schools they will increase in numbers—take engineering courses as a means of gaining an understanding of the technical problems of industry as a preparation for administrative work. Such men need less extensive technical training than the engineer. They need much wider training in the economic and social sciences and in their application in the fundamentals of management of which the management of human relations is a vital part. In some schools courses of study have already been developed to meet this need.

It is essential not to confuse these two problems: the education of the technical engineer, who, if he succeeds, must almost inevitably assume some managerial duties as part of his engineering

[7] Earnings of Land Grant Colleges, by D. S. Bridgman, JOURNAL OF ENGINEERING EDUCATION, XXII, Nov., 1931, p. 189.

[8] For suggestions for courses of this sort see JOURNAL OF ENGINEERING EDUCATION, Oct., 1930, pp. 99–128. "Can the Engineer be Taught to Manage Men?"

but who is none the less a technical expert; and the education of the general executive who in this technical age must understand technology in order fully to grasp the problems of his job, but is none the less essentially a manager. Not to see this distinction will be to impair the development of the engineer and yet to fail to develop the manager—for even in this technical age the positions are distinct. Each in their own way, however, involves dealing with men and often with industrial relations.

In so far as engineering schools train engineers, they are carrying forward an established work. In so far as they undertake to develop technically competent managers, they are taking on a new task. But the surveys of what engineering graduates do and earn, give impressive evidence that in either case it is an important part of engineering education to give students some vigorous training that will equip them to learn from experience to manage men, and that will make them professional in their capacity to deal with the human as well as the material factors of industry.

INVENTORY OF ENGINEERING MOTIVES

By H. S. ROGERS and G. W. HOLCOMB
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The effective counseling of incoming students and the effective differentiation of their aptitudes and interests in engineering have received considerable attention from engineering faculties in recent years. Solutions for the problem of guiding college students have been suggested, or are on trial, but to date no one method has proved entirely satisfactory. The study of human nature and of people remains a complex problem. The total integration of particular conditions which exists around the individual at any time includes a great number of variables which are common to all individuals, such as the quality of intelligence, emotions, health, moral character, aptitude, personality traits, and the large and relatively complex group of motives.

That our engineering colleges enroll many who are of mediocre quality or who would "prefer to do something else," is a condition which is unwholesome both from the student and the college standpoints. As a result of enrolling such students, the engineering schools, and also other schools, have a high mortality between the freshman and senior years. This is a condition which all would like to correct. The various methods by which the problem has been attacked are well known. The generally accepted, by limited methods, are intelligence tests, aptitude tests, and vocational interest tests, each type of which serves its purpose with some degree of effectiveness.

The purpose of the study described herein was to develop an instrument by which a counselor may recognize the dominant motives which describe the attitudes and actions of engineering students prior to enrollment in engineering and which will indicate in a comparative way the intensity of each motive. The traits and scales for engineering motives presented herein were outlined by H. S. Rogers of the School of Engineering at Oregon State College, and the development and tests were made by G. W. Holcomb.

Intellectual motives are of internal, natural origin and are subjective. Those related to college work in engineering may all be instinctive tendencies of childhood, modified and varied through school experiences. They are colorings or manifold aspects of the one driving force, life. H. E. Bennett in *School Efficiency* says, "The child that is 'full of life' is full of motives and full of ac-

tivity," and also ". . . any attitude, habit, interest, or other acquired tendency which is effective for directing or arousing conduct of any sort may be regarded as an impulse or motive." Previously expressed motives should be recognized in college, and students with interests and tendencies opposed to engineering should not be enrolled in engineering. Strong motives opposed to engineering training will eventually drive such away from school.

The engineering motives which drive an individual to do certain elementary things with thorough enjoyment should be the dominant ones of a boy anticipating engineering training. The expert cabinet maker finds delight in constructing a fine piece of furniture. The mathematician will spend hours with an abstract equation and find true pleasure when the correct solution is discovered. Yet, in general, the mathematician will receive no thrill in an attempt to build a cabinet nor will the cabinet maker receive a thrill from a "useless" mathematical equation. Likewise, all of the major divisions of academic study, if analyzed, may show some dominant motives which produce the industry required for the successful pursuit of each activity.

Both of the individuals mentioned above have independent and complex motives or incentives for their work. One may have a motive of craftsmanship, and the other, a motive pertaining to abstract ideas. These same motives were probably in evidence during childhood, although in more elemental form. The skilled cabinet maker when a child probably enjoyed working with tools. He was probably satisfied to work alone and found pleasure in constructing articles of use and beauty. The mathematician, on the other hand, enjoyed the problems in arithmetic and algebra. The most difficult problems were probably always a challenge to him, and he may have taken pleasure in challenging other students with the "nut-crackers."

A study of engineering students indicates that those who are successful in engineering education have some dominant motives which students in commerce, for example, do not have. It would not be expected that a student of commerce would be intensely interested in problems of scientific research; he may, however, have a strong motivation toward transactions of barter and trade. Thus, in all practical fields of engineering, agriculture, medicine, commerce, home economics, etc., there are undoubtedly a small group of distinctive motives predominating each and comparatively independent of the other fields. These dominant motives afford the drives which the student manifests in his own personality. If the group of motives which predominate in one student happen to find opportunity for expression in engineering, the student should select engineering; likewise, the student with commercial motives should find enjoyment in business training.

Engineering Motives

The major interests and instincts which may find expression in engineering training and practice and which will motivate students and practitioners alike seem to be included in the following groups.

1. Constructive instinct.
2. Scientific curiosity in mechanisms.
3. Abstract ideas of a quantitative nature.
4. Precise observation and description of physical things.
5. Practical application.
6. Planning and organization.
7. Manual activity and craftmanship.

The Constructive Instinct.—The advantage that definite constructive ability contributes toward accomplishment in engineering work can hardly be questioned. The continual play with the tools, the putting together and taking apart of things gives a boy an accumulated store of knowledge of the material world.

William James in "Talks to Teachers" says, "Constructiveness is instinct most active." For engineering we desire students in which this instinct is highly developed. We should search for students, who in pre-college days were continually demonstrating a constructive instinct, which James says, "accumulates a store of physical conceptions which are the basis of his (the student's) knowledge of the material world through life." The boy who frequents the blacksmith shop, garage, and carpenter's shop, and enjoys building wagons and mechanical devices, acquires a tendency to build and construct things which carries over into manhood.

Scientific Curiosity in Mechanisms.—Curiosity gives us innumerable expressions, but one kind of scientific curiosity finds expression in a general field which is closely related to engineering. A boy observes a piece of mechanism in a garage and wonders why, or what, or how, and reaches out as intelligently as possible with the partial knowledge which he may possess to satisfy his curiosity. His inquiring mind is always aroused by mechanisms of a scientific nature which he does not understand. Such is scientific curiosity in mechanisms, and the pre-college boy who is aroused by a curiosity of this nature is a prospective student of engineering science.

Abstract Ideas of a Quantitative Nature.—The term, abstract ideas, may be explained as one phase or aspect of an object based upon concepts distinct from the objective features. Good engineering students seem to have an incentive for work with abstract ideas of this kind. Even eminent engineers enjoy challenging their associates with "brain stretchers." The boy who is motivated by a desire for such abstractions will, likewise, enjoy challenging his fellow students with problems which are difficult or new. Any boy

who has a tendency to work with things which are obscure and removed from ordinary physical contacts, yet which have the very foundation of their transcendental nature in the material world, such as the difficult problems of a mathematical and geometrical nature encountered in the high school, has a motive favorable to engineering.

Precise Observation and Description of Physical Things.—The inclination to make accurate quantitative measurements of facts and carefully to describe phenomena, by which changes and relationships are observed, is necessary in engineering work. Likewise, work associated with the physical sciences requires that measurements be taken which are accurate within certain prescribed limits of error. Opinion and vague terms such as, more or less, much and little, when gaging likenesses and differences are not adequate for measures and descriptions when designing structures, writing specifications, or working in the research laboratory. The engineer must know just how much better or poorer one piece of steel is than another. He must be precise in all of his physical observations and descriptions. The high school boy who spends his leisure time reading and comparing the specifications of automobiles or other machines with a critical attitude, or who goes to a machine shop to investigate calipers and other accurate measuring devices, has a motive of precise observation and description which is a characteristic of practicing engineers.

Practical Application.—The purpose of a considerable portion of engineering work is the practical application of theoretical ideas and mechanisms. If a new piece of research work is announced, professional engineers interested in the field immediately inquire for its practical and commercial use. Some will perform experiments of their own to verify the statements made regarding the applications of new theory. Likewise, the engineering freshman, who as a high school student was always testing and putting new ideas into service around the home and school, has this qualification for engineering work.

Planning and Organization.—The value of an interest in planning and organization cannot be over-estimated as a valuable asset to engineers in all divisions of their work. The research man plans his laboratory procedure, the designer lays out and organizes his methods of computation, and the construction engineer plans and organizes the work on the site of the project, in fact, the prophets and fathers of scientific management were engineers. This ability to plan and organize work is manifested in early school days by the boy who keeps his tools in order on the work bench and who likes in advance to plan and organize the procedure of his work.

Manual Activity and Craftsmanship.—The Vocational Interest

Blank prepared by Edward K. Strong, Jr., shows by the weights on the engineer's scale that engineers as a whole have considerable interest in the manual arts. Men who recognize perfection in the operation of both hand tools and machines generally feel a true pleasure when operating them themselves. This pleasure found with the use of tools and machines is manifested in pre-college days by the boy who frequents the manual arts shop of the high school on Saturday afternoons or on holidays in order that he might work with the tools. Boys who are successful in engineering classes are generally interested in making devices which require some degree of skill and craftsmanship.

The foregoing analysis of dominant engineering motives provides a foundation upon which an inventory of incentives and motives was developed for determining the extent to which successful engineering students gave expression to these prior to their college matriculation.

The Inventory Blank

The "Inventory of Engineering Motives" was developed as illustrated by the sample form. Each motive was divided into five qualifying gradations of intensity of satisfaction or enjoyment which a boy might feel when giving expression to the motivation. The motives are not named in the inventory but instead statements qualifying them are made in order that a person marking the blank will not necessarily know the purpose or value of any particular statement.

Each group of qualifications for a motive is arranged, however, with either increasing or decreasing intensity of pleasure. For example, the first five statements of the blank are designed to measure the value of the incentive of constructive instinct in an individual. The statements carry the reader from a feeling of repulsion toward the handling of machines, to a feeling of thorough enjoyment when working with them. Likewise, the statements, numbers six to ten inclusive, classify scientific curiosity. In a similar manner the other motives are gradated by groups of five throughout the blank. The inventory may be made with few or no oral directions as desired. The directions at the top are sufficient for the students' information. It seems advantageous, however, to read the directions orally to students in order that the counselor may be positive that all understand them. No limiting time is required for finishing the blank; fifteen to twenty minutes should, however, suffice for the slowest student.

Scoring

The inventory is scored by means of the form shown in Figure 1, on which the tendencies to motivation are designated by names.

Inventory of Engineering Motives

Name .....Class .....Dept. .....

	(Fr., Soph., etc.)				(C.E., E.E.)
Constructive Instinct	1	2	3	4	5
Scientific Curiosity in mechanisms	10	9	8	7	6
Abstract Ideas of a quantitative nature	11	12	13	14	15
Precise Observation and description of physical things	20	19	18	17	16
Practical Application	21	22	23	24	25
Planning and Organization	30	29	28	27	26
Manual Activity and craftsmanship	31	32	33	34	35

Fig. 1

The horizontal row of numbers following constructive instinct, 1–5 inclusive, refer to the numbers of the statements on the inventory. The first vertical row of numbers, 1, 10, 11, etc., are on the low side of the scale; that is, the side of no motivation, and numbers 5, 6, 15, etc., are on the strong side of the scale or maximum motivation. The middle vertical row may be considered as a modicum of motivation.

A scorer may encircle the numbers on the scoring blank which corresponds to the number checked by the student on the inventory and obtain a profile of the student's motivating tendencies by connecting these numbers with an irregular line. Such a profile furnishes the counselor an accurate survey of the motivating tendencies of a student, which is valuable for use in interviews.

Characteristics of the Inventory

The justification of the use of the seven motives and the exclusion of all others is predicated upon the hypothesis that they are the important and dominant motives of practicing engineers. Observations of results obtained from the use of the inventory seem to indicate that the selection of the seven motives was valid, although additional motives could be included, which are important to particular branches of engineering. The validity of the inventory blank can be established, however, only in terms of its usefulness in vocational guidance and personnel work. Experimental use of the inventory seems to indicate some significant values in diagnosing student interests.

For the purpose of testing the validity of the inventory, it was scored by 204 engineering freshmen during the first two weeks of

the college year 1931–32, and for comparison it was scored by 88 commerce freshmen and 25 vocational education seniors and graduate students about the same time. Figure 2 shows the profile of the average scores for each of these groups. The average scores of the engineering group are considerably higher than either of the other groups. The percentage difference in group scores between commerce and engineering is 22 per cent in the case of "Scientific Curiosity" and 2 per cent for "Planning and Organization." The former is the maximum variation. It is significant to note that lesser differences between the groups occur in the two motives, "Planning and Organization," and "Practical Application," than occur in the other five. Students in commerce should in all probability be expected to score as high as engineers in planning and organization which the results verify. The score for vocational education students would be expected to vary from the other two since these students are interested in a variety of subjects, such as engineering, agriculture, mathematics, commerce, and natural sciences.

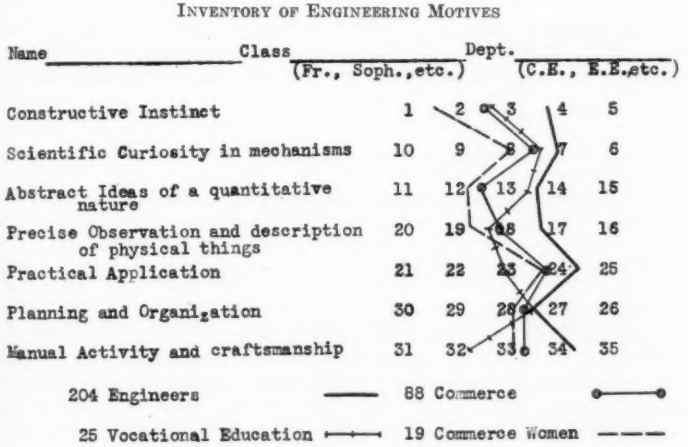
INVENTORY OF ENGINEERING MOTIVES
Name
Class
(Fr., Soph., etc.)
Dept.
(C.E., E.E., etc.)
Constructive Instinct 1 2 3 4 5
Scientific Curiosity in mechanisms 10 9 8 7 6
Abstract Ideas of a quantitative nature 11 12 13 14 15
Precise Observation and description of physical things 20 19 18 17 16
Practical Application 21 22 23 24 25
Planning and Organization 30 29 28 27 26
Manual Activity and craftsmanship 31 32 33 34 35
204 Engineers
88 Commerce
25 Vocational Education
19 Commerce Women

FIG. 2

The profile of the average scores for 19 women students in commerce is also drawn in Fig. 2. Their average is below the average of the other groups for the first four motives, the ones which are predominantly scientific and engineering in nature while it is well within the other groups on the last three.

Figure 3 gives (1) the composite profile of a group of nineteen students who transferred from the School of Engineering to other schools of the institution such as forestry, agriculture, and vocational education, (2) the composite profile of all engineering freshmen, and (3) the profile of 33 engineering students with the highest grade averages.

These 19 students who transferred all received failing grades

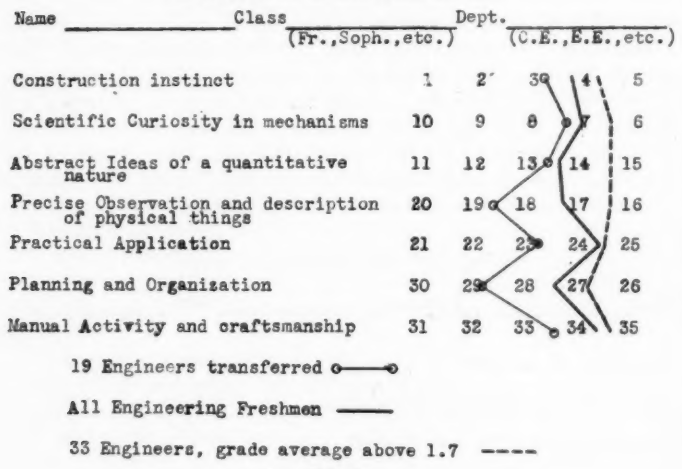
INVENTORY OF ENGINEERING MOTIVES
Name
Class (Fr., Soph., etc.)
Dept. (C.E., E.E., etc.)
Construction instinct 1 2 3 4 5
Scientific Curiosity in mechanisms 10 9 8 7 6
Abstract Ideas of a quantitative nature 11 12 13 14 15
Precise Observation and description of physical things 20 19 18 17 16
Practical Application 21 22 23 24 25
Planning and Organization 30 29 28 27 26
Manual Activity and craftsmanship 31 32 33 34 35
19 Engineers transferred
All Engineering Freshmen
33 Engineers, grade average above 1.7

FIG. 3

in one or more engineering courses, which fact was probably the principal reason for the change in their curricula. The profile of this group shows a motivation which is considerably less than the motivation of the entire group of freshman engineers. The profile for the group of 33 leading engineering freshmen who received grade averages of 1.75 or better for the first term allows a ready comparison of the degrees of motivation which might be expected in good and poor engineering students. Seventy-one per cent of the students who received high grade averages recorded only two motives as average in quality of intensity, and the others above average, while sixty-four per cent, on the other hand, of the group which transferred out of engineering each recorded two or more motives below average in quality of intensity as determined by the middle statement on the rating blank.

It may be reasonably concluded that the inventory blank provides the vocational counselor or personnel officer with a valid in-

strument by which he can quickly picture a student's engineering motives. When an interview is given, the profile instantly describes the motivating tendencies and saves considerable time for the counselor. It also affords a suitable comparison with other students who are, or are not, successful in engineering study. The inventory may be scored by students at the beginning of the freshman year, before trouble develops, and before any student has "something to hide." After a student finds himself in difficulty he may naturally and unconsciously cover up important motives which might influence a counselor's decision. Continued use of the inventory has shown that a knowledge of engineering motives when used in conjunction with an intelligence test and the high school record of a student is of considerable importance when diagnosing individual cases.

It seems possible that similar inventory blanks could be constructed for other divisions of learning. An inventory for business administration would in all probability include a motive describing in a comparative way the attitude of a student toward problems of barter and trade. The same inventory would, on the other hand, not include the motives of manual activity and craftsmanship, or scientific curiosity in mechanisms. The limited experience with this inventory of engineering motives suggests wide possibilities for similar tests.

INVENTORY OF ENGINEERING MOTIVES

Name .....Class .....School .....
(Fr., Soph., etc.) (Engr., Com., etc.)

Directions: The following list of interests and activities describe some of the attitudes and actions of students prior to their enrollment in college. Read them carefully noting the EXTENT of interest or action in all cases and check with a cross those which describe your actions and feelings before your entrance to college:

1. Never *cared* to use tools or handle machinery and avoided them. ( )
2. *Used* tools, *made* home repairs, and *maintained* machinery *ONLY* as it was necessary. ( )
3. Liked to *repair and overhaul* engines and machinery and all things around home. ( )
4. Liked to *build* wagons, mechanical devices, and electrical apparatus and *did build SOME*. ( )
5. Enjoyed *building* machinery, engines, electrical apparatus, and instruments and did so *CONTINUALLY*. ( )

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6. Took delight *ALWAYS in seeking and finding explanation* of performance of machines, tools, and devices about home, garage, shops, or laboratory. ( )
7. *AT TIMES took* machines and devices *apart* to find out how they worked and sought scientific explanation. ( )
8. *Liked to know* how and why home, auto, or farm mechanisms worked. ( )
9. Was *satisfied* with the *explanations* of how and why machines and devices worked as these were *encountered* in duties and tasks. ( )
10. Paid *NO particular* attention to explanations of performance of things and machines and *did not examine* them. ( )

11. Did *NOT* like mathematical explanations and problems. ( )
12. Did assigned mathematical work in average manner *WITHOUT particular* pleasure. ( )
13. *Liked to do* assigned mathematical work but gave *little extra* thought to such things. ( )
14. Was *DETERMINED to work* difficult and tricky problems which were presented by teachers and associates. ( )
15. Took *delight* in working *hard* problems of mathematical type encountered in school and in finding hard ones to challenge associates. ( )

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16. *ALWAYS sought and enjoyed* exact and quantitative descriptions of things like specifications of autos, etc., and *enjoyed using* exact measuring instruments. ( )
17. *Liked to get* exact descriptions of performance of airplanes, cars, etc., and *like to work* with micrometers, microscopes, etc. ( )
18. Dissatisfied with general description of things and *wanted measurements* for comparative purposes. ( )
19. Accepted accurate and quantitative descriptions as encountered but *did NOT seek* them out. ( )
20. *Did NOT like* accurate measuring and gave no particular attention to detailed comparison of physical things. ( )

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21. Believed interests and activities should *NOT be evaluated* in terms of practical use. ( )
22. Gave *NO thought* to *practical* nature of interests in work or play. ( )
23. Had *SOME interest* in practical things but was *NOT particularly satisfied* by their practical nature. ( )
24. Liked to work or play *ONLY* with things that were of *practical use.* ( )
25. Found *MUCH satisfaction* in the *practical* nature of things with which you worked and played. ( )

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26. Found *much satisfaction* in *organizing* tools and work and in *planning* procedure and *ALWAYS did so.* ( )
27. *Liked to* plan and organize all work and activities and *USUALLY did so.* ( )
28. Outlined and planned *required* work upon initiative. ( )
29. Planned and organized details of work *ONLY* when it was required. ( )
30. *Disliked* planning and organizing work or activities. ( )

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31. *Avoided* work requiring manual operations and skill of a crafts nature. ( )
32. Did work requiring manual activity and skill with *indifference.* ( )
33. Worked at *assigned* tasks requiring manual activity and skill *with satisfaction.* ( )
34. *Liked* working with tools requiring skill and action and *did so AT TIMES* for pleasure. ( )
35. Found *MUCH satisfaction* in craftsmanship with hand tools and enjoyed *FREQUENTLY using* machines that required manual operation and skill. ( )

ENGINEERING GRADUATES OF LAND GRANT COLLEGES AND UNIVERSITIES

By DONALD S. BRIDGMAN
American Telephone & Telegraph Company

Introduction

The article "Earnings of Land Grant College Alumni and Former Students" which appeared in last November's issue of this Journal discussed the entire group of men covered by the 1928 Survey of the United States Office of Education. The present article briefly presents a few additional data concerning the earnings of all the engineering graduates included and concerning the occupations and positions of those graduates from four typical Land Grant institutions.

The Earnings of Engineering Graduates

The following table (Figure 1) gives the distribution of those engineering graduates for whom earnings data were available, by types of engineering training and number of years out of college

Fig. 1

Engineering Graduates of Land Grant Colleges

Type of Training	Years Since Graduation							
	1	5	10	15	20	25	30	Total
Civil	568	457	411	477	249	168	150	2,480
Electrical	729	651	331	347	231	157	122	2,568
Mechanical	485	485	285	321	240	135	133	2,084
Other	632	600	217	188	216	144	105	2,202
Total	2,414	2,193	1,244	1,333	936	604	510	9,334
In Engrg. Work	1,808	1,516	690	724	493	348	242	5,821

when their latest earnings were reported. Its final line shows the number of graduates classified as in engineering work by the Office of Education report.

The 5,800 men, shown here as in engineering work, include those who classified themselves as professional engineers, as in work

closely allied to engineering, and as in teaching in the engineering field. All but 300 or 400 of them had been graduated from college with engineering degrees. Of the engineering graduates, about 30 per cent at 1 and 5 years out of college and about 50 per cent at 10 years and more out, are not classified as in engineering work. The great majority of these men are in business or commercial positions, although a few are in teaching or professional work, outside the engineering field, or in miscellaneous occupations.

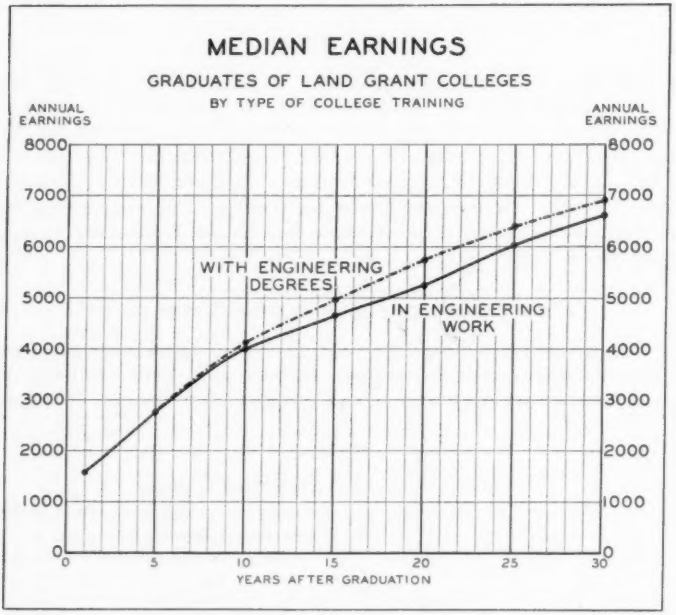


FIG. 2.

The median earnings of graduates with engineering degrees and of those in engineering work are shown by the accompanying chart (Fig. 2). The difference in these two medians is due, of course, to the substantially higher earnings, on the average, of engineering graduates who have given their occupations as "Business" rather than "Engineering." It arises, moreover, mainly from the fact that the percentage of men earning $10,000 or more a year is about twice as large for the former group as it is for the latter. In many cases, these men are merely those who have advanced out of technical and into managerial positions. To that extent, therefore, the dis-

tinction made is a purely artificial one and no conclusion would be warranted that the average engineering graduate would earn more money should he undertake some non-technical occupation. Fundamentally, this chart merely shows that the earnings of men in engineering work by no means give a fair picture of the earnings of all engineering graduates.

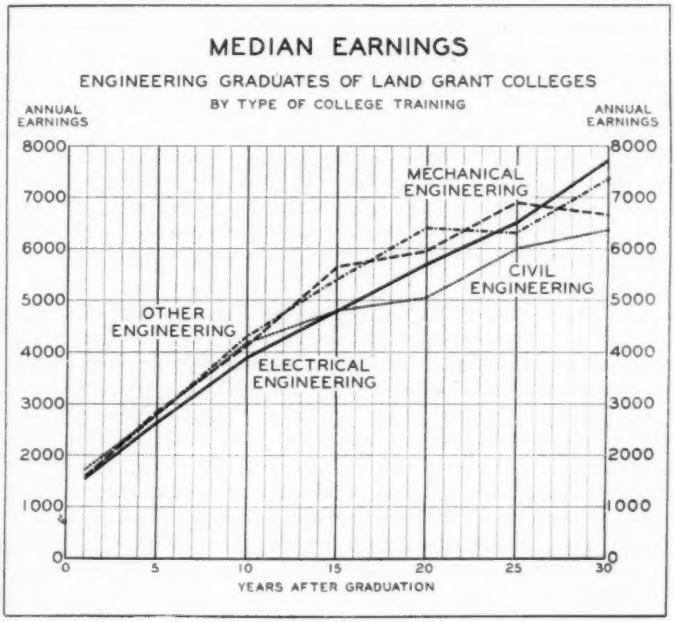


FIG. 3.

The next chart (Fig. 3) gives the median earnings of those men who were graduated in the several principal engineering courses. In the group designated as "Other" are included the chemical, mining, and architectural engineering graduates and similar smaller groups. Although, in general, when one considers the size of each of these groups, the differences in the medians are not striking, a number of them are statistically significant and they do suggest some interesting factors.

The graduates in civil engineering, for example, receive the highest initial salary but their median earnings beyond 20 years after graduation are the lowest shown for any group. It seems clear that the character of much civil engineering work is a handi-

cap to steady progress in earnings. On the other hand, the graduates in electrical engineering earn substantially less than the other groups at 5 and 10 years after graduation but at 30 years out their median is the highest of all, although their advantage over the mechanical and "other" graduates at that point has not much statistical significance. It is probably true, however, that moderate early salaries followed by more substantial recognition later, are characteristic of the progress of men in those large organizations which employ many electrical engineering graduates. The graduates in mechanical engineering show the highest median earnings at 15 and 25 years after graduation. At the earlier point, their advantage over the other groups except that designated as "other" is quite marked; at the later, its significance from a statistical point of view is small. Chance factors, too, probably account, at least in part, for the drop in this median between 25 and 30 years after graduation. The earnings of the "other" graduates, on the whole, compare rather favorably with those shown for each of the three more definite groups.

The United States Office of Education report contained earnings distributions for men engaged in civil, electrical, mechanical, and other engineering work. Medians constructed from those distributions show relationships between groups which, in general, parallel those indicated here for the men graduated from the several engineering curricula. The one exception is in the markedly higher earnings of the "other" group at 20 to 30 years out obtained there but the number of men involved is distinctly small. Again, with that exception, all the medians for groups engaged in the several types of engineering work beyond 10 years out of college, are lower than those shown here for the graduates of the different curricula.

The Occupations of Certain Engineering Graduates

In developing methods for the general study of the Land Grant College Alumni data, the Engineering Foundation, under whose auspices this study was conducted, first examined original questionnaires returned by the graduates of four typical institutions located in different parts of the country. These questionnaires included detailed information concerning the occupations of these graduates, which was tabulated for those receiving engineering degrees. The remainder of this article is concerned with that information and, incidentally, the light it may throw on the earnings data already presented.

In most cases, the questionnaires gave both the present positions of the graduates and the general fields of business or the professions

FIG. 3

Analysis of Occupations

Engineering Graduates of 4 Land Grant Colleges

Business or Profession	Clerk Drftm. Surv.	Fore-man	Design Dev. & Res.	Other Engrg.	Chief Engr.	Acctg. & Stat.	Sales	Spsvry. or Staff	V.P. or Genl. Mgr.	Pres., Owner, Partner	Individ. Practice	Tot. Clsfd.	Pos. not given	Tot.
Manufacturing	10	12	35	104	11	2	80	150	31	50	—	485	14	499
Government	5	—	11	73	2	—	1	13	2	—	—	107	39	146
Lt., Power & Gas	—	2	4	61	—	2	13	35	7	—	—	124	1	125
Const., & Contract	3	—	7	39	1	—	1	23	6	37	6	123	1	124
Tel. & Tel.	1	3	8	83	1	1	5	20	1	—	—	123	—	123
Education: College	—	—	3	—	—	—	—	7	—	—	—	10	101	111
School	—	—	—	—	—	—	—	9	—	—	—	9	51	60
Trade	1	—	—	—	—	—	15	28	2	34	2	82	5	87
Consulting Engr.	1	—	5	33	1	—	—	3	4	19	13	79	1	80
Mining, Oil	—	3	2	20	4	—	3	22	6	3	—	63	1	64
Railroads	4	4	2	19	3	—	1	12	2	1	—	48	1	49
Banking, Invest.	2	—	—	5	—	9	6	8	4	2	3	39	8	47
Insurance	1	—	—	11	—	1	12	9	3	6	1	44	2	46
Iron & Steel	1	3	5	10	—	—	7	12	—	1	—	39	—	39
Architecture	5	—	6	3	1	—	—	2	—	11	2	30	7	37
Agriculture	—	—	—	4	—	1	1	2	1	14	7	30	—	30
Law	—	—	—	—	—	—	—	1	—	3	5	9	8	17
Real Estate	—	—	—	—	—	—	1	5	—	4	—	10	1	11
Advertising	—	—	—	—	—	—	1	2	—	2	—	5	1	6
Retired	—	—	—	1	—	—	—	1	2	2	—	6	3	9
Other	—	—	—	2	—	4	2	5	1	9	1	24	11	35
None	—	—	—	—	—	—	—	—	—	—	—	—	14	14
Total Classified	34	27	88	468	24	20	149	369	72	198	40	1,489	270	1,759
Business not given	32	6	63	300	6	5	72	77	6	11	—	578	11	589
Total Number	66	33	151	768	30	25	221	446	78	209	40	2,067	281	2,348

in which they were engaged. The information is tabulated in Fig. 3. This table is rather complicated but it does bring out some interesting facts. Of the men whose business or profession is given, 80 per cent are in industry, consulting work, or college teaching, fields in which their technical training should be of direct value. This compares with only 60 per cent of the engineering graduates from all institutions classified as in engineering work and the difference is not likely to be due to the fact that these men came from selected institutions. Evidently, as has already been suggested, the general occupational classification for many of the men in sales, supervisory, or major executive positions in industry has been "Business," not "Engineering," and these men have contributed to the higher medians for engineering graduates as compared with those in engineering work. On the other hand, this table does show that 10 per cent of these graduates are in such commercial fields as trade, banking and investment, insurance, real estate, and advertising, thus indicating flexibility in the uses for their training.

Of more than 2,000 men, whose positions are given, only 99 are in such minor ones as those of clerk, draftsman, surveyor or foreman, 949 are holding definitely engineering positions, and 873 are

FIG. 4

Present Positions
Engineering Graduates of 4 Land Grant Colleges
By Years of Matriculation

	1889–91*	1899–01	1909–11	1919–21	Total
Total Number Classified	157	362	509	1039	2067
	Percentages of Total				
Clerk, Draftsman, Surveyor	1.3	2.2	1.8	4.5	3.2
Foreman	—	—	1.4	2.5	1.6
Design, Development and Research	1.9	2.2	5.1	11.0	7.3
Other Engineering	28.0	28.7	26.5	46.7	37.1
Chief Engineer	3.2	2.5	2.2	.5	1.4
Accounting and Statistics	.6	.5	.4	1.9	1.2
Sales	1.9	9.4	11.6	12.0	10.7
Supervisory or Staff	28.0	23.2	28.8	16.5	21.6
Vice Pres., and Gen'l Mgr.	6.4	10.0	5.1	.6	3.8
Pres., Owner, Partner	24.2	17.4	14.9	3.1	10.2
Individual Practice	4.5	3.9	2.2	.7	1.9
Total	100.0	100.0	100.0	100.0	100.0

* One institution only.

in supervisory, staff or major executive positions, are owners or partners in their own businesses or in individual practice. Although the "supervisory or staff" classification includes a wide range of jobs such as superintendent, district manager, supervisor of methods, some of which are not important, the proportion of this whole group in substantial positions is impressive.

FIG. 5

Business or Professions
Engineering Graduates of 4 Land Grant Colleges
By Type of College Training

	Elec. Engrg.	Mech. Engrg.	Civil Engrg.	Other Engrg.	Total
Total Number Classified	392	332	326	709	1759
	Percentages of Total				
Manufacturing	26.0	44.3	13.8	28.9	28.4
Government	3.8	3.9	18.4	8.2	8.3
Light, Power and Gas	18.1	5.1	4.3	3.2	7.1
Constr., and Contract	4.8	3.6	19.3	4.2	7.1
Tel. and Tel.	21.7	4.5	1.8	2.4	7.0
Education: College	4.6	8.8	4.0	7.2	6.3
School	3.1	3.3	1.8	4.4	3.4
Trade	3.6	6.3	4.6	5.2	4.9
Consulting Engineer	2.8	2.1	11.0	3.7	4.5
Mining, Oil	.8	1.5	1.8	7.1	3.6
Railroads	2.3	2.4	7.4	1.1	2.8
Banking, Invest.	2.3	1.5	3.4	3.1	2.7
Insurance	2.0	2.7	3.1	2.7	2.6
Iron and Steel	.3	3.3	1.5	3.1	2.2
Architecture	—	.3	—	5.1	2.1
Agriculture	.5	1.8	.9	2.7	1.7
Law	.3	.9	.3	1.7	1.0
Real Estate	.3	.9	1.2	.4	.6
Advertising	.8	.6	—	.1	.3
Other	.8	.9	.9	3.7	2.0
Retired	.5	.3	.3	.7	.5
None	.8	.9	.3	1.0	.8
Total	100.0	100.0	100.0	100.0	100.0

As would be expected, a larger proportion of the older men are in the more important positions. This is shown by the table given as Fig. 4, where these men are divided by the years of their matriculation in college. In general, there is nothing surprising in this table. The percentage of men in design, development and research,

or other engineering positions drops sharply for the classes matriculating in 1909–11 as compared with those for 1919–21 while the percentage in supervisory or staff and major executive positions increases greatly.

The relations between type of engineering training and present business or profession are shown by the final table (Fig. 5). Once again the data given are not unexpected. Possibly, the most striking thing shown is the fact that at least a few men of each type of training have entered practically every field of work included. The different percentages shown for the less important fields are certainly not significant but the characteristic occupations for the majority of each group are clearly brought out. The relatively large proportion of the civil engineering graduates in governmental work and construction or contracting undoubtedly explains in part their relatively low earnings some years after graduation. Conversely the high proportion of the electrical engineering graduates in public utility work contributes to employment stability for this group and consequently to its opportunity for steady financial progress.

PRESENT STATUS OF ENGINEERING REGISTRATION *

By PARKER H. DAGGETT

Dean, College of Engineering, Rutgers University

Ten years ago, any attempt to discuss the subject of engineering registration usually resulted in a highly heated argument. On the one side would be a group of the younger men who had not yet made their mark in the profession; on the other were ranged the patriarchs of the profession, firm in their conviction that neither the public nor the engineering profession could possibly gain through licensure of professional engineers by the State.

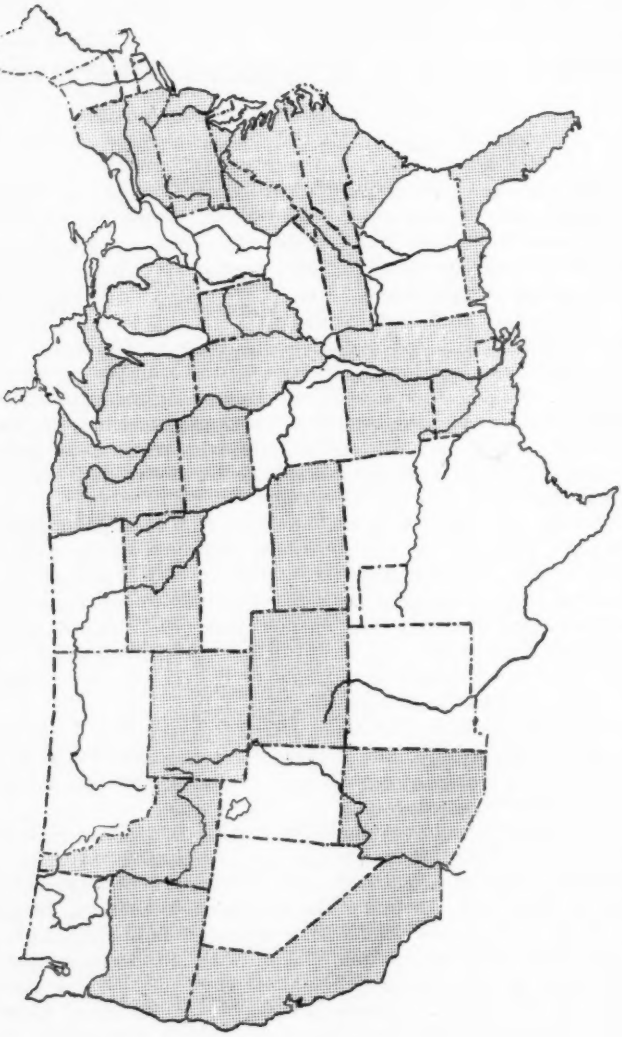
To many, engineering registration is still a highly controversial subject. On the other hand few engineers outside of the civil engineering branch have been touched by the question one way or the other. They have neither bothered with it nor been bothered by it since more than 90 per cent of the registered engineers in the United States are civil engineers.

Within the last few years, however, this movement has gone forward quietly but steadily until now a majority of the states have more or less comprehensive laws governing the registration or licensing of professional engineers. One prominent engineer who has been opposed to registration now recognizes "the inevitability of it," so that in the very near future the question may well be not "What are we going to do about registration?" but "What are we going to do *with* registration?"

It is not at all in the spirit of controversy that I venture to discuss the matter, but rather to set forth the situation as it exists today, and to point out certain aspects that are of vital interest to you as engineering educators.

Wyoming seems to have been the first state to have a registration law for engineers. The law was passed in that state in 1907. Louisiana followed a year later, and by 1920 seven states had registration laws. As shown on the accompanying chart, twenty-six states, covering 55 per cent of the area and embracing more than 65 per cent of the population of the United States, now have laws governing the practice of professional engineers. These states include New York, New Jersey, Pennsylvania, Virginia, West Virginia, North Carolina, South Carolina, Florida, Mississippi, Louisiana, Arkansas, Tennessee, Indiana, Illinois, Michigan, Wisconsin,

* Presented at the Meeting of the Land Grant College Association, November 17, 1931, Chicago, Ill.



Minnesota, South Dakota, Iowa, Kansas, Colorado, Wyoming, Idaho, Oregon, California and Arizona. During the past year registration laws were passed by the legislatures in Ohio and in Washington, but were vetoed by the governors of these states, in the first because the law provided for the licensing of corporations and partnerships, and in the second because the law was too drastic.

In a few states the law covers only one branch of engineering, *e.g.*, in Illinois, structural engineering, and in Louisiana, California and Wisconsin, civil engineering. But twenty-one out of the twenty-six states have comprehensive laws embracing all branches of professional engineering.

The number of years of professional experience required for a license varies from ten in Pennsylvania, West Virginia and Kansas, to none in Louisiana. In the latter state, however, an examination is required which could not possibly be passed by a person without a reasonable amount of professional experience. Table I shows that the majority of the states require at least six years' experience.

TABLE I

State	Number of Years of Professional Experience	Graduation from Approved School Plus Years Experience
Arizona	6	2
Arkansas	4	2
California	6	2
Colorado	7	3
Florida	3	0
Idaho	6	0
Illinois	6	4
Indiana	6	2
Iowa	6	2
Kansas	10	4
Louisiana	0	0
Michigan	6	2
Minnesota	6	2
Mississippi	6	1
New Jersey	6	4
New York	8	4
North Carolina	5	0
Oregon	6	2
Pennsylvania	10	2
South Carolina	4	0
South Dakota	6	2
Tennessee	4	0
Virginia	6	0
West Virginia	10	4
Wisconsin	7	3
Wyoming	8	4

For graduates of an approved engineering college seven states require no professional experience, ten require two years and

six require four years. In a few states the law specifically recognizes engineering teaching in an approved school as equivalent to practical experience. Where the law does not specify, however, the majority of the boards have so considered it.

Practically all of the laws contain a clause under which the several boards have been obliged to register an applicant on his sworn statement that he was actually making his livelihood by practicing engineering at the time the law went into effect. These clauses usually carry the proviso that application must be made within one year from the time of the passage of the act. This provision, which has come to be known by the state boards as "the grandfather clause," has been responsible for a great deal of the unjust criticism to which some of the boards have been subjected. Under it, they have been obliged to register a number of applicants who otherwise would have been turned down. Experience has shown that the registration boards have been able, in one way or another, to eliminate many of these "grandfathers," and the situation in this respect will, of course, gradually right itself, as it did with the lawyers and physicians whose registration laws were initially handicapped by these same grandfather clauses.

One of the earliest problems which the registration boards encountered was that of reciprocity between states. In order to solve this problem, the boards in existence in 1920 organized the National Council of State Boards of Engineering Examiners consisting of one representative from each state board. The purpose of this Council, as defined in its constitution, is "to promote uniformity of practice in the administration of state registration laws for professional engineers and land surveyors, to establish and maintain a system of national qualification for registration, to provide for reciprocal relations between state boards, and to foster any movements having for their aim the promotion of the public welfare through engineering registration, and the improvement of professional standards."

This body in 1923 adopted Articles of Agreement on Reciprocal Registration under which a so-called Reciprocal Card could be issued to properly qualified registrants. This card has been recognized, by those boards which have subscribed to the Articles of Agreement, as *prima facie* evidence of qualification. The membership in this Council now comprises twenty-four of the twenty-six boards, and twenty-one boards have been issuing reciprocal cards under this plan.

At the annual meeting of the Council last month, machinery was set in motion, following the suggestion of T. Keith Legaré, Chairman of the Committee on Registration of Engineers of the American Society of Civil Engineers, by means of which there is to

be established a National Bureau of Engineering Registration. The purpose of this Bureau is indicated by the following committee report which was adopted by the Council.

"1. We agree that there should be a National Bureau of Engineering Registration under the auspices of the National Council, to function as a fact-finding and certifying body.

"2. The Bureau should be self-supporting by means of fees charged to applicants.

"3. The office of the Bureau should be in some central location.

"4. The purpose of the Bureau should be to investigate and verify the records of applicants, and to issue to those who fully comply with the standard requirements for registration adopted by the Council, a 'Certificate of Qualification' which may be used as evidence of qualification—for registration in those states agreeing to recognize said certificates, for membership in state and national engineering societies, for presentation to engineering colleges in connection with the award of professional degrees, for presentation to clients when soliciting contracts for professional services, and for presentation to employers when applying for positions.

"5. The Bureau should be administered by a Committee of the National Council, assisted by an Advisory Committee of representatives from the National Engineering Societies, all details of organization, finance, personnel, location and administration to be worked out by this committee."

This is the method by means of which reciprocal relations between the Architectural registration boards are maintained. The committee is expected to report on the plans for the Bureau at the next annual meeting of the Council which will be held in New York City next Fall.

One of the most significant events in the history of registration, and one which the writer believes will eventually be of vital interest to the engineering colleges, occurred last summer when at a conference of representatives of twenty national and state engineering organizations definite educational standards were adopted as part of the general requirements for registration in the Model Registration Law. This Model Law has been used in the past as the basis of practically all of the laws that have been passed, each state making such modifications as have been found necessary to fit local conditions.

At the present time, only one state, New York, has any educational requirements in its registration law and that only demands a high school education. As stated in the new draft of the Model Law, "minimum evidence satisfactory to the board that the applicant is qualified for registration as a professional engineer" shall be

(*a*) "Graduation from an approved course in engineering of four years or more in a school or college approved by the board as of satisfactory standing; and a specific record of an additional four years or more of active practice in engineering work, of a character satisfactory to the board, indicating that the applicant is competent to be placed in responsible charge of such work."

Graduation is thus placed at the head of the list of three possible methods of qualifying. Those who cannot qualify by graduation must have had eight years of acceptable experience and must pass an examination "designed to show knowledge and skill approximating that attained through graduation from an approved four-year engineering course," or must have had twelve years of lawful active practice, including five years in responsible charge, and must be not less than 35 years of age.

Regardless of the time it may take to translate these recommendations into legal requirements, it is nevertheless significant that the engineering profession has agreed to adopt educational standards on a par with those of the other learned professions.

One further point in connection with the registration laws will be of interest to you as representatives of the engineering colleges in this country. Practically all of the laws as they now exist place upon the registration board the duty of determining what is an engineering school of approved standing. At the time the Articles of Agreement were drawn up by the National Council, no attempt was made to go further than to define an approved school of engineering as one which "requires the equivalent of a high school or preparatory school diploma as an entrance requirement, and demands the equivalent of a four-year course in engineering for graduation."

For some time it has been felt that more comprehensive and discriminating standards were needed. Accordingly, at the last meeting of the Council its Committee on Accredited Schools was directed to proceed with the classification of engineering schools, according to standards to be determined in coöperation with the professional organizations concerned. This committee is now formulating its method of procedure, and will welcome advice and assistance from any source.

As I stated at the outset, this discussion has been presented not with the idea of stirring up a controversy. I am not arguing whether the registration of professional engineers by the state is right or wrong; whether it is a success or a failure; or whether it is a necessary or a wholly useless accessory of the modern state. The fact remains that engineering registration is an accomplished fact for a majority of the citizens of the United States.

The unsatisfactory status of registration is due in no small measure to the fact that the laws in many cases met such violent opposition. Many of the most bitter opponents have now become converted, however reluctantly, and are using their influence to build up rather than to tear down. In the words of the editor of one of the national engineering journals who, when asked by a disgruntled registrant if he had a license, replied, "If the editor were engaged in engineering practice he would have a license, he would deplore the present status of registration, he would conspire to elevate its public significance and professional import and hope by this route to lift engineering practice out of the trade levels and into professional respect."

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Practical Problems. We once had a colleague who taught mathematics. He yearned to give his students "practical problems." Accordingly he stopped us one day and asked for a "practical problem." "Such as, for example"? He replied: "How much would it cost to dig a tunnel,—or how much electricity would a copper wire carry"? This colleague had a commendable ambition: he wanted very earnestly to vitalize his course, to catch and to hold the interest of his students in mathematics. Judging by his idea of the practical, we always wondered how successful he was.

A very pertinent discussion of this question is scheduled for the Corvallis meeting of the Division of Engineering Drawing. Much valuable information and many stimulating ideas should result from the papers and discussions on "What Constitutes a Practical Problem in Descriptive Geometry." It is to be hoped that some of these will be: (1) Does descriptive geometry have to be "practical"? (2) What, in the last analysis, is the objective to be sought for in a course of descriptive geometry? (3) Does the mental training given by a well conducted course justify the study of descriptive geometry.

Too frequently engineering students are invited to measure courses by the so-called "practical values." We might remind ourselves frequently that training in the *scientific method* is, after all, one of the greatest values of engineering study. The contribution made by the study of descriptive geometry in this direction is not to be ignored.

An Appraisal. To review the subject matter of engineering courses of twenty-five years ago is an interesting, informative, and amazing experience. Such an inventory is well worth the time of any teacher who yearns to be practical! The fact will be discovered that basic changes have taken place which render the so-called "practical applications" of a relatively few years ago obsolete. Had engineers not thoroughly demonstrated their ability to think imaginatively and constructively, to study, and to solve problems, there would be little to recommend the "practical" instruction of the early part of the century.

MACHINE DESIGN CLEARING HOUSE

FRANK L. EIDMANN

Chairman, Machine Design Clearing House, Columbia University

Summer Work in a Commercial Drafting Room.—Mechanical Engineering students of Columbia University are required to work for four weeks in a commercial drafting room. This work is done during the summer following the course in Machine Elements.

The student is expected to find his own position. The aid of the professor is, however, sometimes necessary. Industrial concerns have coöperated to make the plan a success and without exception the students have been placed and have been given opportunity to do the regular work of the drafting room as well as to study the plan of organization and drafting room procedure, and to obtain the data necessary for a comprehensive report. The accompanying COURSE SPECIFICATIONS are suggestive of the requirements for the work and the report.

It is interesting to note that it is not at all unusual for the firm to invite the student to take a permanent position after his graduation. In practically all cases the employer has written enthusiastic endorsement of the plan and has expressed satisfaction with the student's work. Columbia University has found the plan highly satisfactory.

SPECIFICATIONS

MACHINE DESIGN (SUMMER WORK)

M. E. 1458

Students—Second year Mechanical Engineers
Time—4 weeks during summer in drafting room of shop

This course is to supplement the work of Machine Design M. E. 141–142, the object being to familiarize the student with commercial drafting room procedure by having him work in the drafting room of a manufacturing plant or machine shop; also to give the student a correct view of the relation of the drafting room to the other departments, it being impossible for the college or university course to create the atmosphere that exists in the manufacturing plant. The student should become familiar with the general conditions which are mentioned in the following outline and should cover them in his written report.

1. The company, its products and its general organization. Draw a chart of the company's organization as a whole. On the chart show the relation of the Engineering Department and Drafting Room to the other departments: sales, general management, purchasing, shops and others.

2. Make an organization chart of the Engineering Department itself. Explain the organization and function of the Drafting Room.

3. Drafting Room Procedure. Methods employed in receiving and distributing orders. Trace the path of an order through the Engineering Department and Drafting Room, the path of the order from its chief draftsman and from him to squad boss, designers, checkers, draftsmen, blueprinting and mailing. If printed forms are used, include copies thereof in your report.

4. The Kind of Work Done. Is the drafting chiefly concerned with the design of the product or of its application?

5. Standards Adopted. Scales used; size of drawings; methods of dimensioning; methods of indicating tolerances; conventional methods of representing parts. Does the company have a book of standards? Are record tracings made on vellum or tracing cloth? In pencil or ink? Procedure in making preliminary layouts, layout of assembly and detail drawings. Checking of new designs in reference to shop facilities by conference with representatives of the shop management, sales department (as to competitive requirements) and with representatives of the pattern making, foundry, machine and tool design departments. Is it the policy of the design department to plan machines to be made of standardized "unit assemblies" which may be used on a variety of types and sizes of machines?

6. Bills of materials or list of parts and materials for a machine. Who writes the bill of material? What information is included? How many copies are made and who receives them? In what form are they manifolded—printed, blue-printed, carbon copies, etc.? What is the procedure in making alterations in the bill of materials after it has been distributed?

7. Systems of filing and storage of finished designs (in both tracing and blue print form) in vaults or fireproof rooms. What is the procedure in borrowing tracings or blueprints from files? What assurance is there that all obsolete blue prints are returned from the shop after changes are made on drawings? Disposal of obsolete drawings? Storage of duplicate set of prints in another building or plant.

8. System of assignment of drawing numbers, part numbers and pattern numbers. What change is made in the drawing numbers when a change is made on a tracing?

9. Number of men employed in drafting room. Class of men. (Are many college men employed?) Duties and titles of each, such as chief draftsman, designers, detailers, tracers, checkers, computors, file clerks. Are women employed in the drafting room? Is there a "calculating squad"?

10. Is the estimating on special orders done in the Engineering Department? Describe procedure. What units are used for estimating costs of construction—pounds, piece, or any other standard?

11. Use of formulas in design work and their source. Reference book or papers. Are catalogs used extensively in design work?

12. Methods of following up the work outside the drafting room by designers or draftsmen.

13. Where are the blue prints made? Describe equipment. What other kinds of prints are used, or methods of duplicating drawings or sketches? Describe processes and equipment and tell under what conditions each different type of print is used.

14. Tell something about the drafting room equipment, *i.e.*, what type of drafting tables, types of tee-squares, drafting machines, etc.? What labor saving devices are used in the drafting room, such as erasing machines. lettering devices, glass top tables for tracing, devices for making broken (dashed) lines; rivet compasses; beam compasses; proportional dividers; pantagraphs; splines and ship curves.

15. Make layout of drafting room.

16. Tell of interesting and unusual things which you learned or observed; *e.g.*, in drafting rooms where photographic copies were made of the drawings, red erasers may not be used because red pigment remaining on the paper would appear as black in a photograph; pencil marks may be removed from tracing cloth without disturbing inked lines by wiping with a cloth dampened with gasoline; use of talcum powder on tracing cloth; if a draftsman employed to do lettering only? Methods of securing drawings to board—thumb tacks, gummed tape, metal staples, etc.; use of celluloid or cardboard stencils for parts of drawings to be repeated; use of dimensioned photographs of parts instead of drawings; tracings with solidly inked blocks for main dimensions so that white places will appear on blue prints, thus facilitating the use of the same tracing for difference projects (frequently used on pulley drawings and on foundation layouts); shellacing of blue prints which are mounted on cardboard for shop use; cross section paper on which the lines may be washed off.

17. Method of keeping costs of drafting room work and assigning same to individual jobs.

18. To be included in the report: samples of student's drawings; copies of printed forms used in the drafting room, including a sheet from a bill of material.

19. Accompanying his report the student is required to submit a letter from the head of the drafting room station: (*a*) how long he worked in the drafting room; (*b*) nature of his work; (*c*) whether his work and conduct were satisfactory.

Each student will find his own job for summer work. It is expected that the student will be put to work under the head of the drafting room and be subject to all rules and regulations in force for regular employees but that opportunity will be afforded to gain sufficient knowledge of the methods employed to write a comprehensive report on the same.

The report is due on the first Monday in November. Late reports receive corresponding credit.

It is recommended that the student read the following papers before doing his summer work in drafting:

"Organization and Supervision of the Design Department," by John F. Hardecker (a series of six papers appearing in *Machine Design* from September, 1929, to February, 1930).

"Machine Design Management," by J. L. Alden, a paper presented at the Annual Meeting of the A. S. M. E., December 1, 1931.

Chapter IV, "Economic Control of Engineering and Manufacture," by Frank L. Eidmann; published by McGraw-Hill Book Co.

NEW MEMBERS

DAWSON, EUGENE F., Assistant Professor of Mechanical Engineering, University of Oklahoma, Norman, Okla. J. H. Felgar, J. F. Brookes.

FANTOLI GAUDENZIO, Professor and Director, Royal Politecnico, Senator of the Regno d'Italia, Milano, Italy. B. F. Groat, J. R. Freeman.

GLENN, EDGAR W., Associate in Engineering Drawing, A. & M. College of Texas, College Station, Texas. A. Mitchell, F. C. Bolton.

LIVINGSTON, ROBERT T., Assistant Professor of Mechanical Engineering, Columbia University, New York City. J. W. Barker, T. H. Harrington.

WABNITZ, WILLIAM S., Assistant Professor of English, University of Cincinnati, Cincinnati, Ohio. C. W. Park, H. B. Luther.

131 new members 1931–32.

BOOKS AND AUTHORS

Author	*Book*	*Publisher*
Anderson, H. T.	Steam Power and Internal Combustion Engines	McGraw-Hill
Morgan, J. J.	Manufactured Gas, American Gas Practice	Morgan

CORRECTION

Professor Timbie brings to my attention a serious error in my paper "A Study of Eleven Representative Electrical Engineering Courses," published in the March number of the JOURNAL. Owing to a misinterpretation of the names of certain English courses at Massachusetts Institute of Technology, I stated that only two units in each semester of the Freshman year are given in the entire course. The fact is that thirteen units are given, consisting of the four mentioned, plus three units in each semester of the sophomore year, plus three more in the last semester of the senior year.

I regret exceedingly having given anyone a possible impression that M. I. T., one of our institutions most distinguished for the thoroughness of its work, would contain so small an amount of English as only four units in its entire E. E. curriculum. My humblest apologies are tendered to the institution.

JAMES C. CLARK.

SECTIONS AND BRANCHES

Kentucky Section.—The spring meeting of the Kentucky Section of the Society for the Promotion of Engineering Education was held at the University of Louisville, on Thursday, April 14, 1932,

at 2:30 p.m. The following program was presented: "The Business Cycle and What it Has to Offer in the Way of Guidance," by Professor C. W. Williams of the Department of Economics, University of Louisville; an address by Mr. M. A. Erskine, District Manager of the Southern Bell Telephone and Telegraph Company of Louisville, Kentucky.

H. H. FENWICK,
Secretary.

The spring meeting of the **Minnesota Section** of the Society for the Promotion of Engineering Education was held Friday, May 13, President George C. Priester, Professor of Materials of Engineering, presiding.

The Minnesota Section was host to a large delegation from Iowa State College and the University of Iowa.

The dinner meeting held at the Campus Club was addressed by Dean T. R. Agg, Iowa State College, and Dr. M. R. Tabue of the State Stabilization and Employment Division.

Discussions were presented by Dean C. C. Williams of the University of Iowa and Professor J. M. Bryant, Head of the Department of Electrical Engineering at the University of Minnesota. The addresses were pertinent to present conditions in the field of education and the looking forward to the new era in scientific training. The statistical analysis concerning unemployment and rehabilitation elicited much interest.

Saturday morning the visiting members were routed through the Engineering Laboratories and then attended a noon luncheon at the Men's Union, at which Professor Frank B. Rowley, Professor of Mechanical Engineering, addressed the meeting on the subject of Air Conditioning.

At 2:00 P.M. a large percentage of the group decided to essay their golf abilities on the University course.

The following officers were elected for the ensuing year:
Professor C. F. Shoop, Prof. of Steam Eng.—Chairman.
Professor E. W. Johnson, Prof. of Electrical Eng.—Secretary-Treasurer.
Professor Lorenz G. Straub, Prof. of Hydraulics—Program.

C. F. SHOOP,
Secretary.

COLLEGE NOTES

Blake Ragsdale Van Leer, who has been Assistant Secretary of the American Engineering Council for the past four years, has been appointed Dean of Engineering at the **University of Florida.** Mr. Van Leer will assume the duties of his new office September 1, 1932.

NECROLOGY

CARL LEO MEES

Dr. Carl Leo Mees, aged 79, president emeritus of Rose Polytechnic Institute, Terre Haute, Ind., died in Terre Haute, April 19, 1932.

Following his resignation of the presidency in 1919, Dr. Mees had served as president emeritus. He came to the school in 1887, from Athens, where he served as professor of physics and chemistry. Previously he had taught chemistry and physics at Louisville, Ky., university. A native of Columbus, Dr. Mees was a graduate of Starling Medical College and Ohio State University and took post graduate work at the University of Berlin.

Probably the best known of Dr. Mees' achievements was the development of a process for photographing microscopic views of human blood and minute tissues. The process was adopted by the army and navy research departments and employed nationally in the detection and solution of crime.

He was a member of the American Association for the Advancement of Science, the American Physics Society, Society for the Promotion of Engineering Education, Indiana Academy of Science and the American Institute of Electrical Engineering.

BOOK REVIEWS

Perspective Drawing. By FRANK W. WALSH. Published by Jeffersons Printing & Stationary Co.

This book differs radically from all other texts on perspective drawing because the perspective drawings are made by means of measurement with a scale and are made with about the same speed, and precision as orthographic drawings.

All types of solids are drawn and each step and use of the scale in their construction is fully illustrated and explained. Five unit lessons cover the various phases of instruction.

The usefulness of perspective drawing and the ability to make them quickly cannot be overestimated and this text presents the subject in a simple and concise manner.

R. F. E.

The Mathematics of Map Projections. By R. K. MELLUISH. Cambridge University Press, Oct. 1931. Price, 8s. 6d. 144 pages.

The impossibility of mapping with absolute accuracy any finite portion of a spherical or spheroidal surface upon a plane surface, has led to many and varied types of map projection. This book

deals comprehensively, yet lucidly, with the mathematical side of the theory of map drawing. "When a map is being drawn each point of it is fixed according to some given law which expresses the coördinates of that point on the map in terms of those of the corresponding point on the earth." It is the derivation and simplication of these equations with which the book is primarily concerned; nevertheless much of the history of the subject is woven into the discussions.

The chapter topics will indicate the nature and scope of the treatise. They are as follows: (1) Introductory; (2) The Simple Conic; (3) Equal Area Projections; (4) Orthomorphic Projections; (5) Perspective Projections; (6) Miscellaneous Projections; (7) The Deformation Projections; (8) Finite Measurements; (9) The Best Projection for a Given Country.

The book is of particular interest to the mathematician, and may be easily read by anyone who has a fair knowledge of the calculus. It should be of practical interest and value to everyone whose work has to do with the construction or interpretation of maps.

K. D. S.

Elements of Electrical Design. By ALFRED STILL. Edited by McGraw-Hill Book Co., Inc., New York. Second edition. 1583 pages, 6 x 9, 229 illustrations. Price $5.00.

This book is not radically unlike the first edition. Some minor changes have been made in the excellent list of test problems accompanying each chapter in keeping with the modern trend toward higher operating voltages and improved efficiencies.

The author says: "The purpose of this book is not to train designing engineers, but to aid the students of electrical engineering in understanding the fundamental principles of electrical engineering through their application to concrete designs."

The first four chapters are devoted to a well written introduction, and then a study of various types of resistance, magnet coils, and electromagnets. Chap. 5, Design of Electromagnets; Chap. 6, Design of Insulation. Beginning with Chap. 7, Professor Still takes up D.C. machinery. He treats the machine in parts, *e.g.*, a chapter on armature of a D.C. generator, another on commutating poles, another on ventilation and temperature rise, etc. Each part is treated thoroughly. A machine typical of its kind is assembled on a design sheet.

The last chapter, 17, in the book deals with mechanical design of electrical machinery. A numerical example is included which

illustrates the method of determining the various mechanical stresses involved in the design for a turbo-alternator. Many other relations are derived and a typical assembly drawing is included of a 400-Kw. dynamo.

The book has so many advantages that many who are teaching electrical design will probably adopt it in the near future. I believe it will become a leader.

R. C. G.

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